8-22-2018 9:30 AM

Pre-service Teachers' Science and Web 2.0 Affect and Aspiration: A Survey Study

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Graduate Program in Education
A thesis submitted in partial fulfillment of the requirements for the degree in Master of Arts

Abstract

Teachers' affect and aptitude towards science and technology influence their students through their teaching, other activities, and informal interactions. The study explored and understand Ontario pre-service teachers' affects toward science and Web 2.0 by designing and validating a questionnaire that includes demographic, usage, and scale questions; and by surveying 134 B.Ed. students. The science part of the survey was validated and analyzed, the Web 2.0 scale items were excluded because of low correlation.

The results indicate that: (1) Pre-service teachers have overall high motivation, high self-efficacy, a positive attitude, and medium aspiration towards science. (2) Science motivation, self-efficacy, attitude, and aspiration scores in the survey can be predicted by other categories; however, self-efficacy and aspiration do not predict each other. (3) Five variables – time spent on learning about science, time using Web 2.0 to learn science, educational background, science-related university major, and teaching option – influence pre-service teachers' science motivation, self-efficacy, attitude, and aspiration.

Keywords: Science, Web 2.0, science education, teacher education, pre-service teacher, motivation, self-efficacy, attitude, aspiration

Acknowledgements

I would like to acknowledge the participants of the research, who kindly provided their opinions, thoughts, and habits, which enabled me to take a glimpse of Ontario pre-service teachers' habits, motivation, self-efficacy, attitude, and aspiration towards science and Web 2.0 technology. Also, I wish to express my thankfulness to the executive staff in Bachelor of Education program for their kind assistance during the research.

I would like to thank my supervisor Dr. Anton Puvirajah for his inspiration and encouragement in constructing the study, and his great patience, flexibility, and guidance in helping me finish this thesis. In addition, I would like to recognize my friend Mr. Yifan Fan for providing me indispensable statistics and technology supports.

Finally, I really appreciate my parents for supporting all my academic paths, both materially and spiritually. I am also grateful for my boyfriend and other friends who have helped me in this journey.

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CHAPTER 1: INTRODUCTION

"Science is the great antidote to the poison of enthusiasm and superstition".

– *Wealth of Nations, Adam Smith* (1785)

The inspiration for this thesis came from an otherwise innocuous comment in a Chinese news story about a professional engineer advocating for Feng Shui practices in building construction to his students. Research shows that engagement with such superstitions and, generally, belief systems not supported by factual data, is common among those in the Arts and Humanities (e.g., Otis and Alcock, 1982; Smith, Foster, & Stovin, 1998; Mowen & Carlson; Abitov et al., 2018), but there is no lack of superstition within the STEM professions as well. Interested in the possibility that this seeming contradiction might exist outside of China along, I am investigating Ontario pre-service teacher's opinions on science and technology using a survey[1].

Problem Statement

In the 21st century, multiliteracies in science, technology, culture and communication is indispensable. Informatization and globalization challenge young citizens in unprecedented ways. Rapid changes in technology, dazzling renewals of cultural sites, and anytime/anywhere communication modes have put forward new demands on the skills that all youth need to master. Science skills, in particular, are essential skills for modern citizens. Second only to science, is technology, especially

[1] Initially, a Web 2.0-related Likert-scale section (22 items) was designed and surveyed to investigate pre-service teachers' affects and Web 2.0 usage habits. However, the principal component analysis results indicate that the Web 2.0 scale questions are not valid for further analysis. As a result, all Web 2.0 scale questions were removed from the analysis as dependent variables.

internet technology. The rapid development of Web 2.0 has influenced the way individuals interact with each other and their environment. If Canada wants to remain competitive in the 21st century, it is necessary that all Canadian citizens gain a certain degree of comfort and knowledge with science and technology (Innovation & Science and Economic Development Canada, 2018; Canada Environment, 2018).

Web 2.0 technology refers to a new series of internet technologies that put emphasis on content collaboration by users. Web 2.0 and its applications, as an important information source in multiliteracies (Cope, Kalantzis & New London Group, 2000; Duncum, 2004), are increasingly influencing students' studying and teachers' teaching, especially in science, technology, engineering and mathematics (STEM) education. However, it is indicated that pupils' interest towards science is fading away. Researchers all over the world, from as early as the 1960s (Walsh, 1968) to the 21st century, have unremittingly focused on the declining engagement in science courses, specializations, and career orientations. One of the important reasons is that, as students advance in school, the science curriculums have become more difficult; hence, students are losing their confidence and motivation in science learning. What is worse is that the lack of interest, confidence or motivation in science might result in teenagers giving up further studies in science, abandoning science majors at universities, and forgoing science-related careers (e.g., Bandura et al., 2001; Mau, 2003; Osborne, Simon & Collins, 2003; Watt & Richardson, 2007).

Research Objectives

To the best of my knowledge, there is no existing survey instrument that measures pre-service teachers' awareness and career ambitions with both science and Web 2.0

taken together. Therefore, in this study, I developed an 82-item survey to determine pre-service teachers' affect and aspirations towards science learning and Web 2.0 utilization. In designing the instrument, I clarified terms and definitions in lay language, confirmed the validity and reliability of the instrument by examining construct internal consistency and principal component analysis, and referenced previous theories and models.

The study aims to understand the nature of pre-service teachers' motivation, attitude, self-efficacy and career aspiration associated with science and Web 2.0, and examine their relationships with demographic factors, like gender, age, ethnicity, parental educational background, education, teaching specialty, and other social factors.

Rationale

Science and Society.

Youths' declining interest in science has been a noticeable phenomenon in the Western world. About half a century ago, Walsh (1968) reported the "youth swings away from science" phenomenon, which led to a series of studies focusing on the decline in students' science study.

Osborne, Simon and Collins (2003) reviewed and summarized the general phenomenon of students' "swings away from science". Many studies also noticed the decline of students' connection with science, as for example interest diminishes as students progress from one grade to the next (Krapp & Prenzel, 2011), and students' motivation for learning science is lower in traditional schools compared to democratic schools where students collaborate with teachers on determining educational focuses (Vedder-Weiss and Fortus, 2011). In addition, the U.S. Department of Education expressed their concern about children's lack of interest in science and mathematics (U. S. Department of Education, 2000, p. 4).

According to the Program for International Student Assessment (PISA) of 15-year-olds' mathematics, reading and science, Canadian students' science engagements (e.g., interest, enjoyment, self-efficacy, motivation, etc.) and science literacy level in 2012 remained relatively high within the Organization for Economic Co-operation and Development (OECD) countries, but lagged behind some Asian (especially East Asian) countries and territories and European countries (Brochu, Deussing, Houme, & Chuy, 2014; Woods-McConney, Oliver, McConney, Schibeci, & Maor, 2014; Woods-McConney et al., 2014). Correspondingly, a 2007 study indicated that in China, students responded with much more positive attitudes towards science and technology; youths master a wider knowledge of science and have more willingness to choose science-related careers (He, Zhang, & Gao, 2007).

While Canada ranks relatively high among OECD countries in terms of educational achievement and economic output, according to the PISA 2006 and 2012, there is a statistically significant decrease in Canadian students' science performance from previous years (Brochu et al., 2014; Bussière, Knighton, & Pennock, 2007). The reports also mentioned that there remains a significant gap between Canadians' science literacy and science, technology, engineering and mathematics (STEM) workforce participation. Since promoting school students' engagement and participation in science has long been deemed by scientists and educators as an essential aspect in benefiting scientific investigation and labor market and economic forces, there is a necessity to gain some understanding of students' and teachers' affects and aspiration towards science.

Multiliteracies and Web 2.0.

Multiliteracies is a term that was first applied in linguistics and refers to synthesizing literacies and other stimulations, including sensual factors (e.g., images, sounds, different versions of languages) and influences from other cognitive, social and cultural contexts (e.g., technology, internet and media) (Cope, Kalantzis, & New London Group, 2000; Duncum, 2004). In science education, researchers have applied the multi-modal construction to scientific knowledge teaching and learning to support students in establishing abilities in comprehensive science literacy, multiple channels of communication, and different subject areas (Unsworth, 2001). Also, government-mandated science syllabuses in Canada and other countries raise demands on students' transference abilities, such as obtaining information from out-of-school resources (e.g., internet and media), and using readily comprehensible forms to present scientific knowledge to the public (e.g., spoken language, images, figurative or symbolic forms) (Ontario & Ministry of Education, 2008, p. 27; Singapore Examinations and Assessment Board, 2016, p. 2).

Information technology, especially Web 2.0 technology, is increasingly playing a significant role in student learning, since it is a very convenient way for people in general to audit, study, and practice multiliteracies skills. No matter what profession they study in or what career they choose, all modern citizens need to be aware of some science and Web 2.0 knowledge.

Population: Why All Teachers?

As we have stressed above, all citizens should have a certain level of knowledge of science and Web 2.0; teachers are no exception. From the constructivist perspective of teaching and learning, students obtain new knowledge by connecting their prior knowledge and present experiences (Chambers & Andre, 1997; Cummins, 1996; Rivet & Krajcik, 2008; Roschelle, 1997). Therefore, teachers' misunderstandings or misconceptions about science literacy and pedagogy limit their teaching aptitude, enthusiasm, and ability to provide high quality learning experiences for their students (Garbett, 2003); worse yet, teachers' science deficiencies are often not obvious to them (Garbett, 2003). This results in false information being provided to students, producing fallacies in communicating with students and misleading instructional approaches (Nehm & Schonfeld, 2007).

Another reason for all teachers to have a certain minimal level of scientific and Web 2.0 knowledge is that the new millennium education requires interdisciplinary teaching skills (National Science Teachers Association, 1996) and the ability to integrate multi-disciplinary knowledge content. Compared to traditional pedagogy, studies continue to show many of the advantages of integrated instruction: it plays an essential part in enhancing learning environments (Bransford, National Research Council (U.S.), & National Research Council (U.S.), 2000), benefiting knowledge reserves and course engagement (P. S. George, 1996), potentially improving grades (Stinson, Harkness, Meyer, & Stallworth, 2009). Without sufficient knowledge of science and Web 2.0 intellectual ability, it is impossible for educators to successfully incorporate science and technology in the classroom.

Study Population: Why Pre-service Teachers?

In this study, I focus on pre-service teachers instead of in-service teachers for two reasons. First, the in-service teachers have a very wide range of ages and experience, from very young to very senior teachers, and a wide range of teaching experience, from very little to very rich; therefore, it is not proper to study them as an undifferentiated group because of this variability. The other reason is that in-service teachers may have a closed mind-set that is biased against internet and/or Web 2.0 technology (Walmsley et al., 2003; Choi, Cristol & Gimbert, 2018).

Compared to the in-service teachers, the pre-service teachers have the following advantages as a research focus. First, pre-service teachers are young, and the age range is quite narrow (most of them are around 21); therefore, it is reasonable to regard them as a group with some common characteristics. Second, they have already started to gain experience with Web 2.0 technology; therefore, they would be more likely willing to react positively to Web 2.0. Third, they do not have much teaching experience and they are more apt to be influenced by interventions such as professional courses and other professional development activities. Additionally, pre-service teachers are a unified sample and are more relevant to the current teacher education situation. Finally, if we get a useful result from the study, the findings might provide information that aids the curriculum design in current pre-service education programs.

Why Develop a New Instrument?

I was not able to find an existing survey that measures pre-service teachers' affects towards science and Web 2.0 together. Although there have been many studies (e.g., Avramidis, Bayliss, & Burden, 2000; Croll, 2008; Elliot & Murayama, 2008; Liaw, Huang, & Chen, 2007; Puvirajah et al., 2015; Uguroglu, Schiller, & Walberg, 1981) focusing on motivation, attitude, self-efficacy and aspiration towards science, few of them target pre-service teachers or the Ontario education context. In addition, most measurements do not include science and Web 2.0 together. If I want to understand Ontario pre-service teachers' affects towards science and Web 2.0, there is a need to construct a new instrument to satisfy my requirement. Hence, in this survey study, an 82-

item questionnaire instrument was utilized to measure pre-service teachers' awareness of science and Web 2.0. To design a comprehensive and reliable scale, two sections (science and Web 2.0) were created; and under each section, four categories were used to measure teachers' viewpoints: attitude, motivation, self-efficacy, and aspiration. In this paper, the collective name for the four categories is called affects. In each of the category, five-point Likert-scale items were provided, and the pre-service teachers were asked to respond to a series of statements related to the four dimensions. Also, with the purpose of exploring the potential factors that influence the participants' positions, a list of demographic information was requested.

Although there have been many instruments developed to determine attitude, motivation, self-efficacy, and/or aspiration (e.g., Avramidis, Bayliss, & Burden, 2000; Croll, 2008; Elliot & Murayama, 2008; Liaw, Huang, & Chen, 2007; Puvirajah et al., 2015; Uguroglu, Schiller, & Walberg, 1981), there was still a need to develop an instrument in this study to measure pre-service teachers' attitude, motivation, self-efficacy and aspiration regarding science and Web 2.0 for the following reasons:

1. For most of the existing instruments, their target population is the students (e.g, Puvirajah et al., 2015; Uguroglu, Schiller, & Walberg, 1981). There are few instruments specially constructed to investigate pre-service teachers. Specific statements were designed for adapting to a student's situation, or focusing on science knowledge, concepts, and scientific literacy, which are not suitable for the pre-service teachers.
2. Many of the instruments were poorly designed and have many weaknesses. Some of the instruments failed to clarify the terminologies in the questionnaires, which

led to participants' comprehension confusion (Osborne et al., 2003); some did not examine or poorly tested validity and reliability.

3. Most of the existing measurements were not specially created for the Canadian and/or Ontario educational context. For example, the self-efficacy measurements do not match Ontario education expectations, or the teacher education context is different from the Ontario programs (e.g, Britner & Pajares, 2006; Liaw, Huang, & Chen, 2007). These limitations reduce the effectiveness of Canadian curriculum-related statements.

Therefore, it was truly necessary to develop a new questionnaire, investigating Canadian pre-service teachers' attitude, motivation, self-efficacy and aspiration towards science and Web 2.0, validating the instrument, and analyzing results with a group of pre-service teachers. This research is a first step to develop a complete, reliable, valid, and Canadianized survey to measure pre-service teachers' affect and aspiration about science and Web 2.0.

How Was the New Instrument Used?

The survey instrument was administered by inviting students to participate in the survey, who were studying in the Bachelor of Education (BEd) program in the Faculty of Education, Western University in Ontario, Canada. Teacher candidates from various streams and specialty areas in the BEd program were asked to participate in the online survey questionnaire anonymously. The collected data was analyzed in four stages. First, descriptive data was sorted out to display the background information from demographic and science and Web 2.0 usage questions. The second stage tested the instrument model by examining the validity and reliability, using construct internal consistency and factor analysis. Third, descriptive statistics was used to describe overall response to the measurements in this study. Last, I explored the significance of relationship between various demographic factors and their responses to the science and Web 2.0 affects survey.

CHAPTER 2: LITERATURE REVIEW

The literature review section focuses on the history of research about motivation, attitude, self-efficacy, and aspiration associated with science and Web 2.0 in the education field. The literatures review the past studies, clarify the key concepts of science, Web 2.0, and motivation, attitude, self-efficacy, aspiration, and integrates the theories about how these affect knowledge and awareness of science and Web 2.0 associated with education, and the relationships with each other.

Themes Present in Current Literature

In this section, the abundant research about science and Web 2.0 affect was reviewed, which helped to show the existing theoretical frameworks, explained the key terms and concepts including the four key categories – motivation, attitude, self-efficacy, and aspiration. Synthesizing these dimensions helped to build the survey instrument, to provide a multi-scale view and to make the survey adaptive to the conditions of Canadian science education.

Motivation, attitude, and self-efficacy are commonly used targets that help to understand people's perception of an item (e.g., Ames & Archer, 1988; Bandura, 1997; Britner & Pajares, 2006; Hein, 2009; Pajares, Johnson, & Usher, 2017; Schunk, 1991; Tsai et al., 2012). In the field of social science, these dimensions have long been used to measure public awareness of a certain social phenomenon; more specific to the field of education, they are often used to understand people's affect, performance, and achievements in academic subjects, knowledge, teaching methods, and so on.

The first three terms are often discussed together within various educational research, to examine or to build theories or models. For example, Schunk (1989) studied self-efficacy and students' behavior in academic learning, concluding that a student's self-efficacy varies with his/her attitude; also, motivation enhances with the progress of his/her self-efficacy, and in turn, lead to a continuous high level of self-efficacy. Zimmerman and Ringle's study (1981) observed the strong relationship between children's confidence and motivation. Collins (1982) argued that the level of self-efficacy could predict students' motivation despite their academic ability level. Schunk (1991) also proposed that the teachers' self-efficacy affects their teaching strategies and further impact their own and their students' motivation and academic performance. Researchers (Singh, Granville, & Dika, 2002) also considered that attitude, motivation, and self-confidence could be significant analytical factors of science and mathematics accomplishment and could further influence students' career aspirations (Eccles & Jacobs, 1986; Reynolds & Walberg, 1992). However, in many studies, these key concepts or points were not explicit. For example, some studies did not give a clear definition, some lack of explanation of "motivation" (Collins, 1982); and some confused or confounded some similar terms, like "self-efficacy" and "self-confidence" (Wilson, Kickul, & Marlino, 2007). Hence, it is crucial to understand and distinguish each of the concepts in my study.

In discussing the four key concepts, it was necessary to explain the two important objects in this study: Science and Web 2.0. "Science" in this research refers to all scientific knowledge and practice in all levels of school and out of school, the enterprise of science, and all natural and information science areas. The Ontario Curriculum: Science (OCS) gives the definition of science as: "Science is way of knowing that seeks to describe and explain the natural and physical world" (Ontario & Ministry of Education, 2008, p. 4). "Web 2.0" is a term that refers to a new series of internet technologies that differs from traditional internet technologies (what we call it Web 1.0, e.g., HTML webpages); Web 2.0 includes collaborative web applications allow content to be created and exchanged and by every user; compared to Web 1.0, the Web 2.0 platform is more dynamic, user-centered, interactive, socialized, collaborative (Lee & Markey, 2014; O'Reilly, 2010, p. 233), regardless of users' devices. Examples of Web 2.0 technologies include blogging, wiki, podcasting, RSS, social bookmarking, social media, social networks, and so on.

Motivation

Motivation is notable for educators because it plays an essential role in students' learning, performance (Ames & Archer, 1988), and academic achievement (Napier & Riley, 1985). Due to the importance of it, many motivation questionnaires, especially learning motivation questionnaires were designed and applied in educational psychology studies. Some of the research focused on understanding students' general motivations, for instance Uguroglu, Schiller and Walberg (1981), explored strong correlations between motivation and academic achievement by administering a multidimensional motivation instrument. Elliot and Murayama (2008) focused on achievement goal questionnaire measuring mastery and performance goals from the approach and avoidance orientations (Cook, Castillo, Gas, & Artino, 2017); Blumenfeld' s goal theory of motivation (1992) stressed that classroom goals vary with changes in school context and subject areas; the self-theories propose that learning goals are the central determinants of the academic achievements (Elliott & Dweck, 1988; Grant & Dweck, 2003). The U.S. National Research Council (Hein, 2009) proposed that students' enthusiasm and motivation in learning is of great importance in supporting science learning. In addition, various studies

(Pintrich & Blumenfeld, 1985; Tuan, Chin, & Shieh, 2005; Urdan & Maehr, 1995) indicate that teachers' social behaviors, such as expectations, encouragement, feedback, and teacher-student interaction could affect students' motivation orientation.

Therefore, it is necessary to recognize and validate the teachers' level of science motivation by developing a robust survey instrument.

Definition

Motivation is a widely-used concept in the education field applied to both youths and adults. It refers to "the attribute that moves us to do or not to do something" (Broussard & Garrison, 2004) in a general way, and Lai (2011) reviewed and paraphrased the definition of motivation as "reasons that underlie behavior that is characterized by willingness and volition" (p. 2). According to self-determination theory (SDT) proposed by Deci and Ryan (2008; 2000b), motivation is usually subdivided by researchers into two distinct classifications, namely intrinsic and extrinsic motivation. Intrinsic motivation grows out of inherent personal enjoyment, interest, or pleasure; and in contrast, extrinsic motivation, is ruled by reinforcement contingencies (Lai, 2011; Ryan & Deci, 2000b).

When discussing the role that motivation plays in learning, Gottfried (1990) defines academic motivation as "enjoyment of school learning characterized by a mastery orientation; curiosity; persistence; task-endogeny; and the learning of challenging, difficult, and novel tasks", but this definition overemphasizes the intrinsic orientation and ignored the extrinsic aspect. Wlodkowski and Ginsberg (2017) defined motivation in learning as "the tendency to find learning activities meaningful and worthwhile and to benefit from them", which give consideration to both intrinsic and extrinsic impetus.

Self-determination theory (SDT) focuses on the orientation of motivation and distinguishes between two main types of motivation: intrinsic and extrinsic. Intrinsic motivation refers to those actions that individuals engage in as they are inherently interesting and enjoyable, while extrinsic motivation refers to individuals engaging in actions because they lead to separable outcomes (e.g., rewards) (Deci & Ryan, 2008; Ryan & Deci, 2000a, 2000b). Usually, researchers and educators think of intrinsic motivation to be more pleasing, more self-driven, and to result in better learning outcomes (Lai, 2011; Niemiec & Ryan, 2009), more positive cognition (Ryan, Connell, & Deci, 1984), more willingness to challenge difficult academic problems (Boyd, 2002; Vallerand & Bissonnette, 1992), and increased creativity (Moneta & Siu, 2002) than extrinsic motivation for it plays a positive role in learning and academic achievement (Osborne et al., 2003). Related cases suggest other attributes of motivation: feeling that science learning is meaningful (Gläser-Zikuda, Fuß, Laukenmann, Metz, & Randler, 2005), need for being curious (Tuan et al., 2005), and so on. A 2005 research study of an internet-based learning model (Lee, Cheung, & Chen, 2005) found that both extrinsic and intrinsic motivators impact learners' intention in applying new learning media. However, extrinsic stimulations like a teacher's feedback (Pintrich & Blumenfeld, 1985; Tuan et al., 2005) is still important to support students' motivation towards learning, especially in science learning.

Still, there is controversy at the boundary of intrinsic and extrinsic motivation. Though traditionally, the teacher's role is seen as determining to extrinsic factors, teachers' leadership theory (Avolio & Bass, 1995) argued that teachers and teachers' experiences influence students' perceptions. Further work on intrinsic motivation for learning, Lu, Chen, Hong & Yore (2016) also support this opinion and expanded that teachers' leadership could interact with and predict students' attitude towards science and thereby motivate students intrinsically.

Besides the intrinsic and extrinsic orientated analysis, Ford (1992) put forward "goal" as another way of analyzing motivation. Considerable studies like achievement goal theories and self-theories have suggested that the goals are important indicators to understand achievement motivations (e.g., Ames, 1992; Ames & Archer, 1988; Elliott & Dweck, 1988; Grant & Dweck, 2003). A widely known model under the achievement goal theory explains students' engagement in their studies using two main goal orientations: mastery goals (MG) orientation and performance goals (PG) orientation (Ames, 1992; Grant & Dweck, 2003). Mastery goals orientation refers to mastering the knowledge and skills the learners aim to "developing new skills, trying to understand their work, improving their level of competence, or achieving a sense of mastery based on self-referenced standards" (Ames, 1992, p. 262); and performance goals orientation refers to demonstrating abilities, the learners "focus on their ability and self-worth, to determine their ability by outperforming others in competitions, surpassing others in achievements or grades, and receiving public recognition for their superior performance" (Ames, 1992, as cited in Linnenbrink & Pintrich, 2002).

Researchers argued that, in general, mastery goals exceed performance goals in learners' cognitive strategies, school learning, and academic engagement (Ames, 1992; Linnenbrink & Pintrich, 2002) because performance goals usually have a relationship with motivation from external rewards or ambition (Pintrich & Schunk, 1996), and mastery goals have more connections with learners' intrinsic desire (Deci & Ryan, 1991). However, intrinsic emotion is more constant and harder to change, so educators made efforts to change external influences like designing teaching strategies, building teacher-student relationship (Brophy, 1998; Pintrich & Blumenfeld, 1985), creating good learning environments or adjusting appropriate expectations (Schunk, 1983, 1985).

Based on the work of Deci, Rayn, Ames, Pintrich and other researchers, this thesis defines **motivation**, in this case specific to research, as the behavior, enthusiasm or desire that drives an individual's actions to learn or to apply science and Web 2.0, regardless of whether that enthusiasm is from a self-contained or external influence, or is goal-oriented.

Motivation Measurement Design

In the survey development, I have synthesized the self-determination theory, and mastery-performance goal theory, by employing these four concepts: (a) intrinsic motivation, (b) extrinsic motivation, (c) mastery goal, and (d) performance goal, as measurement subcategories to understand pre-service teachers' motivation. Compared with other awareness concepts like aspiration, motivation here focuses more on individuals' short-term goals, or on the "demonstrated" targets.

Attitude

Another important dimension in measuring people's behavior is attitude. Educators have long realized that attitude itself or its support to other factors, has an important impact on many aspects of education or learning. For instance, Garner and Smythe (1975) indicated that attitude advances learners' motivation in second language learning; Singh et. al (2002) argued that students' positive attitudes towards mathematics and science could influence their career aspirations in related fields; Kay (1990) observed that attitudes could help forecast the users' computer literacy.

However, as mentioned at the beginning of this paper, there is an abundance of evidence showing decline in youth' interest of science. This decline is specifically reflected in observable trends such as the falling numbers of students devoting themselves to science learning and science-related careers and the undervaluation of science and technology because of accepting pseudoscience (Tsai et al., 2012). Negative attitudes towards science could lead to a series of education, technology, social or economic problems. As a result, educators, economists, governments, and other stakeholders worldwide have been interested in increasing the positive attitude of youth towards science. Publics' attitude towards applying Web 2.0 in the educational process is also controversial; the divergence of teachers and students' attitudes towards internet technologies result in their different usage of Web 2.0 (Baltaci-Goktalay & Ozdilek, 2010; Hartshorne & Ajjan, 2009; Tusubira & Mulira, 2004).

Students' attitudes toward science directly influence their science and technology career aspiration (Osborne et al., 2003; Singh et al., 2002) and have a strong correlation with their life-long interest in science (Lu et al., 2016). Students' and teachers' attitude towards science have always been a considerable influence on their science literacy. Many factors can shape a student's attitude towards. These factors include, but are not limited to, gender, culture (Osborne et al., 2003), whether students' have enough scientific knowledge (Reif, 1986), whether the science curriculum is designed to be practical and interesting (Osborne & Collins, 2000), whether teachers have fair and encouraging teaching styles (Lightbody, Siann, Stocks, & Walsh, 1996), whether there is sufficient activity-based laboratory tutoring (Freedman, 1997), and teacher's attitudes towards science (Osborne et al., 2003). Due to the teacher's direct and indirect impact on students, it is necessary for researchers to understand pre-service teachers' attitudes towards science, no matter whether they will be teaching science majors or non-science majors.

Definition

Attitude has been a key concept in social science for decades. Fishbein and Ajzen's attitude theory (1975) is the classical theory about an individual's attitude that has been applied in many areas including but not limited to education, psychology, economics, and so on (Fishbein & Ajzen, 1975; Mitchell & Olson, 2000). In attitude theory, Fishbein and Ajzen defined attitude as "a learned predisposition to respond in a consistently favorable or unfavorable manner with respect to a given object (p. 6)… a function of his salient beliefs at a given point in time (p. 222)" ; Breckler (1984) defined attitude as "a response to an antecedent stimulus or attitude object"; Petty, Wegener & Fabrigar described attitude as "evaluations of objects along a dimension from positive to negative" (1997, p. 611); and Mitchell and Olson (2000) defined attitude as "an individual's internal evaluation of an object".

The tripartite Model is a very classical attitude theory that divided attitude into three components: cognition, affect, and behavior (Bagozzi & Burnkrant, 1979; Breckler, 1984; McGuire, 1985). These three dimensions refer to an individual's response to the object or the stimulus. In detail, the three components are defined as: (a) Cognitive: a knowledge about the object, the beliefs (the ideas component), which could vary from favorable to un favorable; (b) Affective: various pleasurable feelings about the object (the like or dislike component); and (c) Behavioral: a tendency-towards-action, the objective component, for example, favorable or supportive, to unfavorable or rejective (Breckler, 1984; Reid, 2006, p. 4).

There has been a long history of attitude-related research, studies, models and theories. However, when we focus on the intersection of attitude and science – one of the themes of my research – the concept "attitudes towards science" has lacked clarity. In

1975, Gardner claimed that there should be distinction between “attitudes towards science” and “scientific attitudes”. Blalock et al. (2008) (2008) generalized the four categories measuring students’ science attitudes: (a) attitudes toward science, (b) scientific attitudes, (c) understanding the nature of science, and (d) scientific career interests. In this section of the paper, the central issue is the first category, *attitudes toward science*. The fourth category, scientific career interests, defined as “expressing interest in scientific related careers” (Blalock et al., 2008), is dicussied in the aspiration-related section.

When discussing the attitude towards science, Germann (1988) put emphasis on distinguishing “scientific attitude” and “attitude toward science”. The two analogous concepts that correlate science and attitude are “attitudes towards science” and “science attitudes”. To distinguish the two terms, Gardner (1975, p. 2) sorted the emotional response to all the science-related objects into the concept “attitudes towards science”, including interest, satisfaction, and enjoyment.

Therefore, the **definition of *“attitude”*** used in this study is the individual’s personal judgments, emotions, opinions, and worth about the object. What follows is how people view our research objects, that is, people’s attitude *towards* science and Web 2.0.

Attitude Measurement Design

One objective of this study is to develop an instrument for measuring pre-service teachers’ attitudes towards science and Web 2.0. Although there have been clear definitions of attitude, there was still preparatory work to be done before the measurement instrument was designed. The first problem was to determine which elements in science and Web 2.0 should be analyzed. While we did define science and Web 2.0 at the beginning of the literature review, we broadly defined science and Web 2.0 to covered a wide range of concepts. It was necessary to narrow the focus before designing the instrument. Specifically, three elements in science and Web 2.0 technology are studied particularly: (1) the enterprise of science and Web 2.0, (2) school science and Web 2.0 in school, and (3) the impact of science/scientists/Web 2.0 and technicians on society – referring to Osborne et al. (2003)'s research components in science-related attitude.

Another challenge arises: attitude, itself, potentially contains an unmanageable number of components. When different researchers were developing instruments intended to measure attitude towards science, each assigned a unique set of factors to measure the attitude; A great numbers of factors have been identified that influence attitudes. For example, Germann's instrument, *Attitude toward Science in School Assessment (ATSSA)* categorized five factors that affect students' attitude towards science in school (1988):

1. general attitude toward science,
2. mental strain/course difficulty (five items),
3. testing (four items),
4. labs (two items), and
5. job/reading (two items).

Kind et al. (2007) obtained seven factors that measure students' attitude towards science:

1. learning science in school (6 items) *,
2. self-concept in science (7 items),
3. practical work in science (8 items),
4. science outside of school (6 items) *,
5. future participation in science (5 items) *,
6. importance of science (5 items), and
7. general attitude towards school (8 items).

(*: Combined interest in science)

Furthermore, Osborne et al. reviewed 14 studies (Breakwell & Beardsell, 1992; Brown, 1976; Crawley & Black, 1992; Gardner, 1975; Haladyna, Olsen, & Shaughnessy, 1982; Keys, 1987; Koballa, Jr., 1995; Oliver & Simpson, 1988; Ormerod & Duckworth, 1975; Piburn & Baker, 1993; Talton & Simpson, 1985, 1986, 1987; Woolnough, 1994; as cited in Osborne et al., 2003) and incorporated 11 subcategories used in measuring attitudes towards science:

1. perception of the science teacher,
2. anxiety toward science,
3. value of science,
4. self-esteem at science,
5. motivation towards science,
6. enjoyment of science,
7. attitudes of peers and friends towards science,
8. attitudes of parents towards science,
9. nature of the classroom environment,
10. achievement in science, and
11. fear of failure on course.

Since there are many subconstructs in the existing literatures, I developed a set of factors to use in this study by reassessing the origin of "attitude towards science". As defined above, attitude towards science includes students' judgement, belief, emotion, and behavior towards science. For correlation analysis, five categories were designed to distinguish the issues that affect a student's attitudes towards science and/or Web 2.0:

1. Importance of science/Web 2.0,
2. Interest to science/Web 2.0,
3. Theoretical knowledge about science/Web 2.0 in school,
4. Practical operation in science/Web 2.0 in school,
5. Science/Web 2.0 beyond school.

Self-efficacy

The third important affect category is self-efficacy. It represents how much an individual believes that he/she become capable at a certain goal, task, or skill. Self-efficacy is a concept regarding ability that is related to personal expectancy (Schunk, 1991), and plays a central role in Bandura’s social cognitive theory. According to his social cognitive theory, self-efficacy belongs to a type of self-evaluation that does not only affect how people perform or how much effort people make, but also influences how much willpower people have when they deal with difficulties; in other words, how people master their behaviors (Bandura, 1977, 1982, 1997). Britner and Pajares (Pajares, 2002; Britner & Pajares, 2006) supported Bandura’s view and confirmed that students’ science self-efficacy beliefs support their academic development.

Studies indicated that self-efficacy beliefs are determining factors that impacts human motivation, emotion, and action (Bandura, 1989; Zimmerman, 2000). Specifically, a lot of research has revealed the relationship between academic motivation and self-efficacy. Zimmerman and Bandura (1994, as cited in Chen & Zimmerman, 2007) discovered that in writing skill tasks, learners’ self-evaluative levels were affected by their self-efficacy. Bandura (1997) revealed that higher self-efficacy increases learners’ academic motivation and that, even when the students confront obstacles, they could still maintain strong enthusiasm and perseverance. Pajares and Graham (1999) found the students’ self-efficacy positively related to their academic engagement. Also, Zimmerman and Kitsantas (1999) found that students’ attitudes towards writing tasks related to their self-efficacy; Saks (1995) found that job self-efficacy and attitudes increase simultaneously; Bandura, Barbaranelli, Caprara and Pastorelli (2001) indicated that self-efficacy shapes teenagers’ direction to their career aspirations. Other studies (Zeldin &

Pajares, 2000; Jocz, Zhai, & Tan, 2014) revealed that self-efficacy was a key factor to attract women to embrace a science, math or technology-related career.

Definition

Self-efficacy has long been a popular focus in the research of education and have been defined around key words like “judgements” and “beliefs”. Smith (1989) supposed that self-efficacy represents a judgment of how well an individual can implement something across a variety of situations. Schunk (1991) defined self-efficacy as “an individual's judgments of his or her capabilities to perform given actions”. Bandura (1997, p. 3) defined self-efficacy as the “beliefs in one’s capabilities to organize and execute the course of action required to produce given attainments”.

Bandura’s self-efficacy theory states that self-efficacy positively correlates to individuals’ cognition and behavior. The theory indicates that, individuals who have a higher sense of self-efficacy believe themselves capable for certain tasks, are more likely to treat difficult tasks as challenges that need to be mastered rather than avoided. Further, they persist longer and work harder as they encounter obstacles when compared to less self-efficacy people (Bandura, 1977, as cited in Schunk, 1991). Similarly, Pajares (2000) claimed that learners who lack self-efficacy in their aptitude are less likely to change themselves, and more likely to make excuses for their failure such as inadequacy of their own, innate, permanent abilities.

Researchers have also found that self-efficacy has a major impact in students’ science-related engagement, academic performance, and experience. Studies suggested that students’ confidence in succeeding in science courses, skills, activities or other tasks, guides their science-related plans, influences their academic efforts, determines the willpower to overcome obstacles in learning, and predicts their success in science or technology-related academic achievement (Bandura, 1986, 1997; Britner & Pajares, 2001; Zeldin & Pajares, 2000; as cited in Britner & Pajares, 2006). In other words, a high science ability does not correspond to a high academic achievement or performance, instead, the belief about capability is the factor that determine a person's science-related accomplishment. For example, Chipman, Krantz, & Silver's study (1992) indicated that learners, especially female learners would more likely aspire to science if they confirmed their confidence in science; Pajares, Britner and Valiante (2000) argued that science self-efficacy worked as an indicator to forecast middle school students' science grades, Kupermintz (2002) proposed that science self-efficacy not only predicts high school students' achievement, but relates to the science-related tasks out of school.

Though many studies have revealed the importance of self-efficacy in science tasks, few of them provide a direct definition of science self-efficacy. Britner and Pajares (2006) defined science self-efficacy as "… students' belief in their ability to succeed in science tasks, courses, or activities". Considering this definition and the work of Smith, Schunk and Bandura, in this survey, science self-efficacy refers to an individual's belief about their ability to master science knowledge, skills and tasks, or to achieve other science-related learning goals.

Self-efficacy Measurement Design

According to social cognitive theory, Bandura (1986; 1997) classified self-efficacy beliefs into three dimensions: magnitude, strength, and generality. *Magnitude* refers to how difficult an individual considers a specific task (Bandura, 1977; Crowe & Higgins, 1997); *strength* refers to how much confidence an individual has in his or her ability to perform a specific task (Bandura, 1977; Porter, Bigley & Steers, 2003); and *generality* represents the extent to which an individual extends the professional self-efficacy from a one field to another, or across time (Bandura, 1977; Bandura et al., 1980). Also, self-efficacy is usually cognized to be task-specific (Porter, Bigley & Steers, 2003), which refers to the belief in one's capability regarding a particular task or situation; or generalized nature (general self-efficacy, GSE), which is applicable to a broad range of challenging tasks (Luszczynska, Gutiérrez-Doña, & Schwarzer, 2005; Miyoshi, 2012). Many researchers designed their survey instruments based on a task-specific construct (Britner & Pajares, 2006; P. Chen & Zimmerman, 2007; Chou, Cardoso, Chan, Tsang, & Wu, 2007; C. Lee & Bobko, 1994) originally put forward by magnitude and strength; other researchers focused on comprehensive self-efficacy situations and developed general self-efficacy (GSE) scales (G. Chen, Gully, & Eden, 2001; Judge, Erez, & Bono, 1998; Luszczynska et al., 2005). In this study, I targeted the task-specific strength as the dimension to measure pre-service teachers' beliefs in specific knowledge and skills. However, there are few instruments designed specifically to evaluate task-specific, science and Web 2.0 self-efficacy among Canadian pre-service teachers, there is a need to construct one in science and Web 2.0 fields. Therefore, one must be constructed.

In order to develop an instrument measuring Canadian pre-service teachers' self-efficacy in science, I relied on *Ontario Curriculum: Science* (OCS) (2008), to extract the categories that could classify learners' confidence throughout the process of science learning. Though the target population in this study are the pre-service teachers rather than the students, OCS is an appropriate reference for it is an official, comprehensive, specific government document that covers almost all the expectations in science education, including goals, skills, activities, perceptions and so on. For the whole science program in secondary education, the OCS put forward three science goals to aim for in any course in science program:

1. Relate science to technology, society, and the environment.
2. Develop the skills, strategies, and habits of mind required for scientific inquiry.
3. Understand the basic concepts of science.

In order to make learners achieve these goals and to master science knowledge and skills, the OCS (2008) proposes specific curriculum expectations for science courses in Ontario. These expectations contain overall and specific knowledge and skills that students are expected to master in each of the science courses. To "master" science does not only mean to finish homework or pass examinations, but to meet other requirements in assessment as well. To evaluate how students, meet the curriculum expectations, the OCS provides an out the achievement chart to help teachers to judge students' performance in science learning. The chart categorizes the expectations into four groups:

1. Knowledge and understanding,
2. Thinking and investigation,
3. Communication,
4. Application.

In this study, these expectations are employed to understand pre-service teachers' science self-efficacy, as well as Web 2.0 beliefs.

Aspiration

As mentioned at the beginning of this paper, the younger generation is losing interest in pursuing science courses, professions, and occupations (Council for Industry and Higher Education, 2009). At the same time, the demand for a capable STEM-related workforce continues to grow (Council for Industry and Higher Education, 2009; House of Lords, 2012; UK Commission for Employment and Skills, 2012). To address this issue governments and policy-makers across the world are seeking a variety of methods to promote, stimulate, and encourage young people to participate in STEM. The target populations include but are not limited to the students enrolled in both basic education and higher education, as well as recent graduates in the career development stage (U.S. President's Council of Advisors, 2010). Besides the aim of training more STEM specialists, a wider participation in STEM fields is important not only for economic productivity, but also for developing scientific literacy (Osborne, 2007) and promoting social equity (Durant, 1993). In other words, all citizens have a duty to understand and be involved in developing a scientific society (Archer & DeWitt, 2017, p. 3).

Studies show that young adults' aspiration may be as a good predictor of their profession development path (Croll, 2008). Aspiration as a shaping factor has been discussed in many psychology and educational theories. Lewin's field theory deemed that the strength of aspiration depends on two dimensions: the value that the individual assigns to a potential goal, and the possibility he or her could achieve the goal (Lewin, 1975). In their theory, the status attainment model, Blau and Duncan (1967) considered that for young students, aspiration created one of the most important impacts on their academic achievements and career choices. The model claimed that students' aspirations are primarily influenced by two factors: social dimensions, and personal dimensions (Strand & Winston, 2008). Social factors comprised the importance of environment, including family influences and the resources that the students were able to get access. Examples of the latter include: school, curriculum, gender, ethnicity, family, and social class (Archer & DeWitt, 2017; Archer, DeWitt, & Willis, 2014) Personal dimensions emphasize individualized factors, like psychological health, identities and self-esteem (Archer & DeWitt, 2017).

Definition

Though there are many studies exploring the concept of aspiration, there are few clear definitions of aspiration. Based on Lewin's field theory, Sherwood (1989) put emphasis on two aspects of aspiration, future-oriented and motivators; he defined aspiration as "any goal an individual is willing to invest in beforehand". Wang and Staver (2001) define career aspiration as "a psychological outcome from school". A more widely used, traditional view of career aspiration is the desire that leads an individual to select a specific career (Farmer, 1985). For O'Brien (1996) career aspiration included individuals continuing their educative process within their careers with the expectation upward career mobility.

Integrating the research studies above, the definition for aspiration applied in this study is: aspiration is the future target that an individual is willing to achieve on their education or career stage. In this study, I focus on students' short-term and long-term education plans, their career choices and goals related to science and Web 2.0. Furthermore, I aim to understand the social factors that are relevant to an individual' aspirations.

Aspiration Measurement Design

For educational or career aspiration measurements, most researchers set up aspirations as descriptive statements. For example, a 1989 study (Stage & Hossler, 1989) and 2008 study (Uwah, McMahon, & Furlow, 2008) both classified aspiration questions into demographic questions; educational aspirations responses were chosen from academic degree categories. Dewitt et al. (2013) focused on participants' aspiration through seven questions related to studying and career planning. None of the above research classifed aspiration scales into different levels. O'Brien's Career Aspiration Scale (CAS) proposed three themes in aspiration measurements: aspiring to leadership and promotions, training and managing others, and pursuing further education (O'Brien, 1996); however, the measurements are more applicable to career rather than education.

In my study, the questionnaire includes items to assess respondents' aspirations associated with science and Web 2.0 learning and professional development. The items focus on asking respondents about their intentions for learning science/Web 2.0 for general interest and as part of their professional development as teachers.

Research Questions

My research is a quantitative survey study aimed at understanding pre-service teachers' attitudes, aspirations, motivations, self-efficacy, associated with science and Web 2.0 technology use. The research questions are:

1. What are pre-service teachers' motivation, self-efficacy, attitude, and aspiration towards science?
2. Is there a relationship between pre-service teachers' motivation, self-efficacy, attitude, and aspiration about science?
3. What demographic, science learning, and/or Web 2.0 utilizing factors, if any, are associated with pre-service teachers' motivation, self-efficacy, attitude, and aspiration about science and Web 2.0 technology?

CHAPTER 3: METHODOLOGY

The initial purpose of my research was to investigate pre-service teachers' affect and aspiration towards science and Web 2.0 technology, however, the Web 2.0 scale questions were excluded from descriptive analysis. More specifically, this study intends to explore and comprehend Ontario pre-service teachers' opinions towards science and by designing a questionnaire and analyzing the collected data. The survey items include multiple-choice and multiple-response questions so as to provide information on demographic data and science and/or Web 2.0 usages, and Likert-scale questions to collect affect and aspiration statistics through four dimensions: motivation, self-efficacy, attitude, and aspiration.

Instrumentation

Description of WSSWAA Instrument.

I designed the Western Survey of Science and Web 2.0 Affect and Aspiration instrument (WSSWAA) to measure participants' current affect (motivation, attitude, self-efficacy) and aspiration towards science and Web 2.0 technology. More specifically, the WSSWAA survey aimed to find out:

1. to what degree are pre-service teachers motivated to learn or to use science (motivation);
2. how they value, understand, and judge science (attitude);
3. how much they believe they can master, learn about and apply (self-efficacy);
4. how much they want to pursue studying or careers in science (aspiration);
5. the possible factors (demographic, utilization, internal, external) that influence the science affects.

The WSSWAA survey consists of 82 questions: 19 demographic questions, 41 science-related questions, and 22 Web 2.0-related questions. Among the science-related questions, one is about the usage of science, the other 40 are five-point Likert-scale items separately measuring science attitude (10 items), science motivation (8 items), science self-efficacy (13 items), and science aspiration (9 items). For the Web 2.0 questions, 10 items focus on Web 2.0 usage, and 12 are Likert-scale items that measure the following four dimensions: attitude (4 items), motivation (3 items), self-efficacy (2 items), and aspiration (3 items). For each scale item, the participants responded by selecting from one of five points in Likert-scales: Strongly Agree, Agree, Neither Agree nor Disagree, Disagree, and Strongly Disagree. The structure and number of questions of the survey instrument are shown in Figure 1. Actually, the Web 2.0 part was eliminated from further data analysis for the Web 2.0 scale questions failed to pass the validation check. I will describe the exclusion process later in the principal component analysis part (page 49).

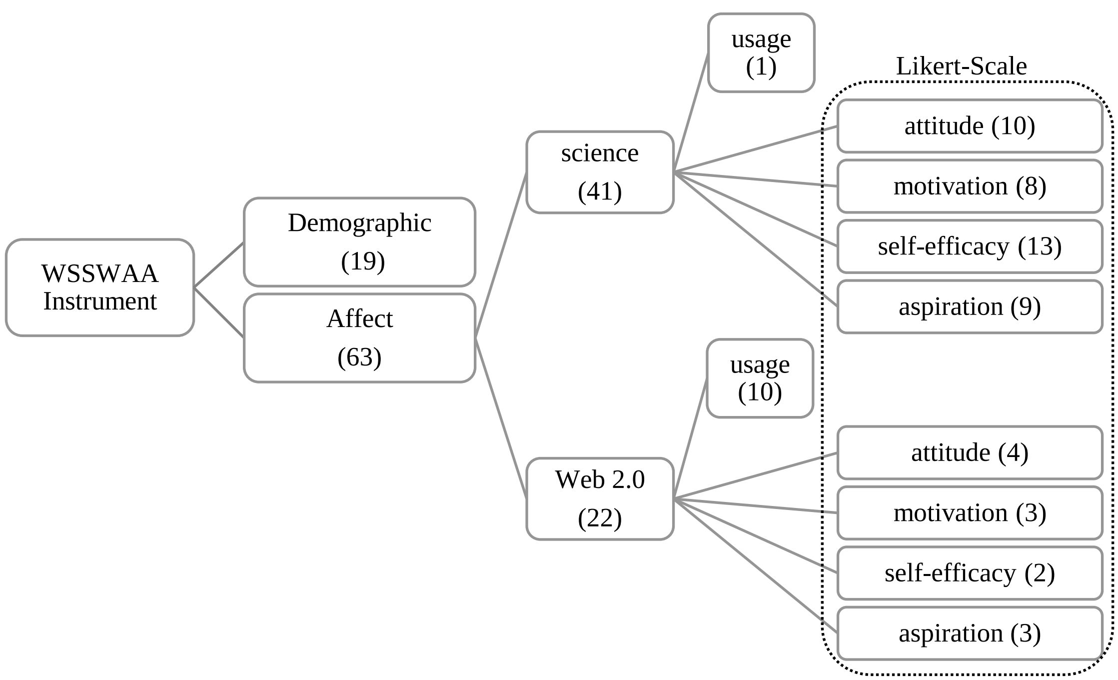

Figure 1. WSSWAA Instrument Structure and Number of Questions

The survey results were returned and coded automatically by the online survey platform, Qualtrics (2018). The records were exported as a Microsoft Excel spreadsheet and to IBM SPSS dataset. The respondents were coded using the following formats:

1. Multiple choice and multiple response (demographic questions and science/Web 2.0 usage questions): the options were re-coded as numbers following the order in which the options appear; the additional entry texts were recorded as strings;
2. The original responses of Likert-scale questions were recorded scale variables: Strongly agree = 1, Somewhat agree = 2, Neither agree nor disagree = 3, Somewhat disagree = 4, Strongly disagree = 5. Before the analysis, the responses were re-coded as Strongly agree = 5, Somewhat agree = 4, Neither agree nor disagree = 3, Somewhat disagree = 2, Strongly disagree = 1. After the factor analysis process, the scores for each item were sum up to calculate the question scores for each category (George & Mallery, 2011, Chapter 1);
3. For the four reversed worded questions (3, 5, 53, 58), the raw records indicated smaller numbers represented more negative opinions, which are opposite for other original questions. Therefore, for the reversed worded items, the responses were kept as smaller numbers represented more negative opinions.

Table 1 and Table 2 present the original Likert-scale items in science and Web 2.0 surveys, in eight categories.

Table 1

The Original WSSWAA Survey Showing All Science Likert-Scale Items

	Science Motivation		***Science Attitude***
2	I like solving challenging science problems.	23	Science is important to society.

3[r]	If I had a choice, I would not study science.	24	Science is helpful for improving people’s daily life.
4	I would be more apt to do science if I know that I will be recognized for my work.	25	I find participating in science (learning and doing) activities interesting.
5[r]	I only took a minimally necessary number of science classes for high school graduation.	26	I keep myself updated with the newest development in science.
6	In science classes/courses, I have always aimed for and worked for high marks.	27	I liked learning science in school.
7	When I was faced with difficulties in understanding science, I tried to use a variety of ways to overcome these difficulties.	28	I liked conducting science experiments in school.
8	In science classes/courses, I would do my best to perform well.	29	I often talk about science questions with my family or friends.
9	One of my aims in science classes/courses was to do better than my peers.	30	I like to observe natural/scientific phenomena in my daily life.
	Science Self-efficacy	31	I like to visit Museum of Science/Nature, or the Planetarium.
10	I believe I can understand and apply the science terminologies correctly.	32	I try to frequently apply science knowledge in real life (e.g. cooking, gardening, sporting, etc.)
11	I believe I can understand most of the science concepts taught in a science class.		***Science Aspiration***
12	I believe I can identify key information in science problems.	33	I plan to participate in science-related formal professional development activities or courses in the near future that are not a required part of the program.
13	I believe I can identify the steps to solve science problems.	34	I plan to keep myself updated with the newest developments in science.
14	I believe I can observe and make clear record of a science experiment.	35	I plan to participate in informal science-related activities outside of my formal certification program. (e.g. robotics clubs, science museums, maker spaces)
15	I believe I can use textbooks, reference books, and internet resources to help me solve a science problem.	36	I plan on enrolling in a science-related post-secondary program.

16	I believe I can use clear diagrams to express science ideas.	37	I plan on taking at least one science-related course from a post-secondary institution.
17	I believe I can make clear and audience-friendly science presentations.	38	I will keep learning science even if it was not required in my profession.
18	I believe I can use formulae and SI units to express science knowledge (e.g., force analysis, chemical reaction, genetic formula; mass, time, length, etc.).	39	I would seriously consider taking some/further science-related courses so that I could be certificated/endorsed in a specific science field.
19	I believe I am able to apply the science knowledge to my other academic work when appropriate.	40	I will keep using science even if my work is not related to science.
20	I believe I can understand new science knowledge and make logical connections to my previous knowledge.	41	I will encourage my future students to pursue science-related coursework/careers.
21	I believe I can explain phenomenon and solve problems in real life using my science knowledge.		
Note	r — negatively worded item that was reverse coded for analysis		

Table 2

The Original WSSWAA Survey Showing All Web 2.0 Likert-scale Items

	Web 2.0 Attitude		***Web 2.0 Self-Efficacy***
52	Web 2.0 technology is useful in my studying.	59	I'm good at using web 2.0 tools to study.
53[r]	Mobile apps are distracting for learning.	60	I'm good at using web 2.0 tools to study science.
54	Web 2.0 apps have more advantages than disadvantages in learning.		
55	Web 2.0 technology is helpful for learning science.		***Web 2.0 Aspiration***
	Web 2.0 Motivation	61	I would like to use Web 2.0 apps to help me learn science if I were in school.
56	I would like to use Web 2.0 tools for studying.	62	I would like to use Web 2.0 apps to help me learn science out of school.
57	I would enjoy using science-related web 2.0 apps for learning.		
58[r]	I would not use science-related Web 2.0 tools for studying, because I would be mistaken for playing rather than studying.	63	I would like to use Web 2.0 apps to help me learn science even after my graduation from university or college.
Note		r — negatively worded item that was reverse coded for analysis	

Survey Distribution and Data Collection.

After the ethics application and proposal were approved, I started to collect data by recruiting participants, distributing surveys and making draws for five $5 *Amazon.ca* gift cards. The survey was posted on a web hosting platform server, *Qualtrics* (2018), which enables automatic online recording, QR code, hyperlink, and email distributing, data storing, and data exporting (including CSV, SPSS, TSV, XML and other formats) functions for an online survey.

The target population of the study was the undergraduate students enrolled in the Bachelor of Education (BEd) program in the 2017/2018 academic year at the Faculty of Education, Western University, Canada. The recruitment stage lasted from February 1st to March 31st, 2018, in Faculty of Education, Western University. The two reasons for choosing this period are: first, the research proposal was approved at the end of January; second, all BEd students were supposed to leave campus for practicum at the beginning of April. For the participant recruitment process, in order to attract as many qualified participants from the Faculty of Education as possible, five means were used to contact possible candidates: (a) posting flyers throughout the Faculty of Education building – about 50 posters were pasted on bulletin boards and around the classrooms; (b) sending emails to course instructors to notify students to take part in the research – about ten teachers kindly helped to distribute the survey link to their students; (c) posting on email list serve directed at pre-service teachers – about 720 emails were sent to all BEd students in the Faculty of Education; (d) visiting about 30 classes with large enrollments of pre-service teachers, making short speeches to provide a brief overview of the research and attracting the BEd students to participate; and (e) distributing study information and invitation cards in the hallways and cafeteria during class transition times in February and March, 2018.

The survey distribution stage was synchronized with the recruitment process, from February 1st to March 31st, 2018. By the end of March, 169 responses were collected. The recruited students were provided at least one of the access methods to the study: a QR code, a full hyperlink of the survey (usually by an email), or a short link (usually by a paper invitation card). The hyperlink first led the students to a page that displayed a brief overview of the study and asked them whether they are 18 years of age or above and are enrolled in the pre-service teacher education program. If they answered both or one of the questions in the negative, they were notified that they were not eligible to participate in the study.

Advancing from the introduction page led participants to a consent page where they were asked for their consent. The implied consent page provided a brief overview of the study and ask the participants to give consent. Those giving consent were presented with the whole survey questionnaire. Participants finished the survey in approximately 10 minutes. At the end of the survey, participants were given an opportunity to submit their email addressed to be entered into a draw to win one of five $10 gift cards for *Amazon.ca*. Entering into the draw was optional and participants were notified that their survey responses and the email information used for the draw would not be associated with each other.

After the completion of data collection, the research team purchased five *Amazon* gift cards, and conducted the draws from among the participants willing to enter and submit their email addresses. The team then contacted the five winners and distributed the gift cards.

Sample

The target population of the study was students enrolled in the Bachelor of Education (BEd) program in the 2017/2018 academic year at the Faculty of Education, Western University, Canada. In total, 744 pre-service teachers were enrolled in the BEd program; 382 of them were in year one, and 362 were in year two. The Western BEd program is made up of three streams: Primary-Junior (P-J; Year 1, 182 students; Year 2, 204 students), Junior-Intermediate (J-I; Year 1, 32 students; Year 2, 32 students), and Intermediate-Senior (I-S; Year 1, 168 students; Year 2, 126 students).

It should be mentioned that when I started to distribute the WSSWAA survey in the Western Faculty of Education, the second-year students had already left the campus for practicum, thus it was very hard to recruit them to participate in the study. Eventually, 169 responses (21.83% of the target population) were gathered for the study, 136 first-year students (35.60%) responded to the survey, which is an adequate sample size for data analysis. For the other participants, 22 were in year two, and 9 responded as “other”.

Another point to be considered before data analysis is that not all participants finished the WSSWAA survey, with 140 of the responders finishing 60% of questions, which is nevertheless sufficient for data analysis. The response rates below 60% were excluded. Eight responses were rejected because the participants did not respond well to the reverse-ordered questions, which are similar questions whose option orders were reversed. Although some resent research is opposed to removing “low-quality” responses(Anduiza & Galais, 2016; Berinsky, Margolis, & Sances, 2016), I decided to set up four attention check questions (Q9, 13, 34, and 60) to distinguish the untruthful or inadequately considered answers (Bolstad, 2017). After rejecting six responses, the actual sample size for data analysis was 134.

As a general rule, the literature (Comrey & Lee, 1992; Hair, 2006; Tabachnick & Fidell, 2007) suggests that there should be no less than 100 samples for a study; also, the high enough sample size for a survey study should be at least five times larger than the number of the survey items (Zwick & Velicer, 1986). In this study, as mentioned above, the samples for the study were recruited from the Bachelor of Education (BEd) program, Faculty of Education, Western University; the actual sample size for data analysis was 134, which meets the criteria for 27 questions, to analyze both science and Web 2.0 attitude/motivation/self-efficacy/aspiration categories separately, in eight separate surveys. As the science and Web 2.0 areas and attitude/motivation/self-efficacy/aspiration categories are independent from each other, indicating that the 41 questions do not come together to form a whole survey construct, I treated them as eight separate surveys.

Table 3 shows the summary of background information of the participants, including demographics, science learning, and Web 2.0 usage statistics. In addition, Table 4 displays the science and Web 2.0 learning and usage items in the forms of multiple-choice and Likert-scale questions. The scale items in Table 4 will be analyzed as potential predictor variables.

Table 3

Background of Respondents

Variables	**Options**	**Frequency**	**Percentage**	**Valid Percentage**
Gender	Female	99	73.9	73.9
	Male	29	21.6	21.6
	Other	2	1.5	1.5
	N/A	4	3	3
Grade	1st year	119	88.8	88.8
	2nd year	15	11.2	11.2
	Unreported	0	0	
Program	Primary-Junior	48	35.8	36.6

Variables	Options	Frequency	Percentage	Valid Percentage
	Junior-Intermediate	11	8.2	8.4
	Intermediate-Senior	71	53.0	54.2
	Others (please specify)	1	0.7	0.8
	Unreported	3	2.2	
Age	20-24 years old	95	70.9	72.5
	25-29 years old	26	19.4	19.8
	30-34 years old	9	6.7	6.9
	35 years old and above	1	0.7	.8
	Unreported	3	2.2	
Ethnicity / Race	White	90	67.2	68.7
	North American Aboriginal	2	1.5	1.5
	South Asian	8	6.0	6.1
	East Asian	11	8.2	8.4
	South East Asian	4	3.0	3.1
	Black	3	2.2	2.3
	Arab	1	0.7	0.8
	Multi-Identity	10	7.5	7.6
	Others	2	1.5	1.5
	Unreported	3	2.2	
Ethnicity / Race	White	90	67.2	68.7
(White/Others)	Others	41	30.6	31.3
	Unreported	3	2.2	
Education Attainment	Bachelor's degree	124	92.5	94.7
	Master's degree	7	5.2	5.3
	Unreported	3	2.2	
STEM Educational	STEM-related	44	32.8	33.6
Background	Non-STEM-related	87	64.9	66.4
	Unreported	3	2.2	
Science-related post-	Yes	41	30.6	31.3
secondary major	No	90	67.2	68.7
	Unreported	3	2.2	
Specialty area	STEM-related	15	11.2	12.0
	Non-STEM-related	110	82.1	88.0
	Unreported	9	6.7	
Teaching option	STEM-related	35	26.1	27.8

Variables	Options	Frequency	Percentage	Valid Percentage
	Non-STEM-related	91	67.9	72.2
	Unreported	8	6.0	
Mother’s highest education attainment	Less than secondary school/high school	3	2.2	2.3
	High school (or secondary school) graduate	22	16.4	16.8
	Some postsecondary education	12	9.0	9.2
	Trade/vocational diploma or certificate	3	2.2	2.3
	College diploma or certificate	37	27.6	28.2
	Bachelor's degree	36	26.9	27.5
	Professional degree (e.g., MD, LLB, DDS)	6	4.5	4.6
	Master's degree	8	6.0	6.1
	Doctoral degree	2	1.5	1.5
	Not applicable	2	1.5	1.5
	Unreported	3	2.2	
Mother's Profession	STEM-related	41	30.6	31.3
	Non-STEM-Related	90	67.2	68.7
	Unreported	3	2.2	
Father’s highest education attainment	Less than secondary school/high school	8	6.0	6.3
	High school (or secondary school) graduate	21	15.7	16.4
	Some postsecondary education	10	7.5	7.8
	Trade/vocational diploma or certificate	7	5.2	5.5
	College diploma or certificate	28	20.9	21.9
	Bachelor's degree	25	18.7	19.5
	Professional degree (e.g., MD, LLB, DDS)	7	5.2	5.5
	Master's degree	12	9.0	9.4
	Doctoral degree	7	5.2	5.5
	Not applicable	1	0.7	.8
	Don't know	2	1.5	1.6

Variables	Options	Frequency	Percentage	Valid Percentage
	Unreported	34	4.5	
Father's Profession	STEM-related	54	40.3	41.2
	Non-STEM-Related	77	57.5	58.8
	Unreported	31	2.2	
Parental STEM profession	STEM-related	70	52.2	53.4
	Non-STEM-Related	61	45.5	46.6
	Unreported	3	2.2	

Table 4

Science and Web 2.0 Learning and Usage Responses

Variables	Options	Frequency	Percentage	Valid Percentage
Science-related study or activity hours/week	1 hour or less	65	48.5	48.5
	1 ~ 2 hours	26	19.4	19.4
	2 ~ 3 hours	19	14.2	14.2
	3 ~ 4 hours	9	6.7	6.7
	More than 4 hours	15	11.2	11.2
	Unreported	0	0	
Time spend on mobile devices hours/week	3.5 hour or less	6	4.5	4.5
	3.5 ~ 7 hours	15	11.2	11.2
	7 ~ 10.5 hours	28	20.9	20.9
	10.5 ~ 14 hours	29	21.6	21.6
	More than 14 hours	56	41.8	41.8
	Unreported	0	0	
Time using Web 2.0 for learning hours/week	2 hours or less	22	16.4	16.7
	2 ~ 4 hours	35	26.1	26.5
	4 ~ 6 hours	33	24.6	25.0
	6 ~ 8 hours	27	20.1	20.5
	More than 8 hours	15	11.2	11.4
	Unreported	2	1.5	
Time using Web 2.0 for science learning hours/week	2 hours or less	104	77.6	78.8
	2 ~ 4 hours	16	11.9	12.1
	4 ~ 6 hours	9	6.7	6.8
	6 ~ 8 hours	1	0.7	0.8
	More than 8 hours	2	1.5	1.5

Variables	Options	Frequency	Percentage	Valid Percentage
	Unreported	2	1.5	
Web 2.0 is helpful for science learning	Strongly agree	53	39.6	40.2
	Somewhat agree	54	40.3	40.9
	Neither agree nor disagree	21	15.7	15.9
	Somewhat disagree	4	3.0	3.0
	Strongly disagree	0	0	0
	Unreported	2	1.5	
Enjoy using science-related Web 2.0 for learning	Strongly agree	50	37.3	38.2
	Somewhat agree	61	45.5	46.6
	Neither agree nor disagree	15	11.2	11.5
	Somewhat disagree	3	2.2	2.3
	Strongly disagree	2	1.5	1.5
	Unreported	3	2.2	
Good at using Web 2.0 for science learning	Strongly agree	7	5.2	5.3
	Somewhat agree	21	15.7	16.0
	Neither agree nor disagree	46	34.3	35.1
	Somewhat disagree	45	33.6	34.4
	Strongly disagree	12	9	9.2
	Unreported	3	2.2	
Subject studied using Web 2.0 in high school	Yes, STEM-related subject	69	51.5	51.9
	Yes, but not STEM-related subject	36	26.9	27.1
	None subject	28	20.9	21.1
	Unreported	1	0.7	

Data Analysis

For the second, third and fourth research purposes, a quantitative data analysis process was carried out; and the three research questions were answered by the results. First, demographic information of respondents and science and Web 2.0 usage statistics were determined as shown in descriptive Table 3 and Table 4 (see page 38 ~ page 43). Second, a principal components analysis (PCA) (Jolliffe, 2002) together with Cronbach's alpha construct was applied to examine the construct validity and reliability of WSSWAA instrument. In the third step, descriptive statistics of scale survey items was calculated to answer the first research question. The last step was to explore the relationships among demographic information, background statistics, and scale data, by using multiple linear regression, independent *t*-tests, and analysis of variance analyses; and the second and the third research questions would be answered. Multi-linear regression is used to explore the potential predicting variables, and build predicting models for the question scores; independent *t*-tests is applied to examine if there is a significant difference on question scores between two groups in a variable; and analysis of variance (one-way ANOVA) is used to check if there is a significant difference among the groups in a variable.

CHAPTER 4: RESULTS

This chapter explicates the statistical analysis procedures and results. First, general trends of the demographic and science and Web 2.0 data to provide contextual background to the survey responses. Second, a principal component analysis process was applied to the questionnaire to make it more concise, to explore a more equitable structure for the survey, and to extract the factors within the survey. Then, to gain a general understanding of the participants' perceptions and usages of science and Web 2.0, descriptive statistics for Likert-scale question scores were performed. Finally, multi-linear regression, independent *t*-tests, and one-way ANOVA processes were implemented to investigate the possible relationships between the variables and the survey question scores.

Data Description

The target population of the survey are the Bachelor of Education (BEd) students in Faculty of Education, Western University, Canada (744 students). After removing incomplete and low-qualified responses, the actual sample size of the survey was 134, sampling rate is 18.01%, which meets the criteria for 27 questions. The distribution of respondents' demographic and other backgrounds is shown in Figure 2, and distribution of their science learning and Web 2.0 usage is shown in Figure 3.

Figure 2. Demographic Background of Respondents

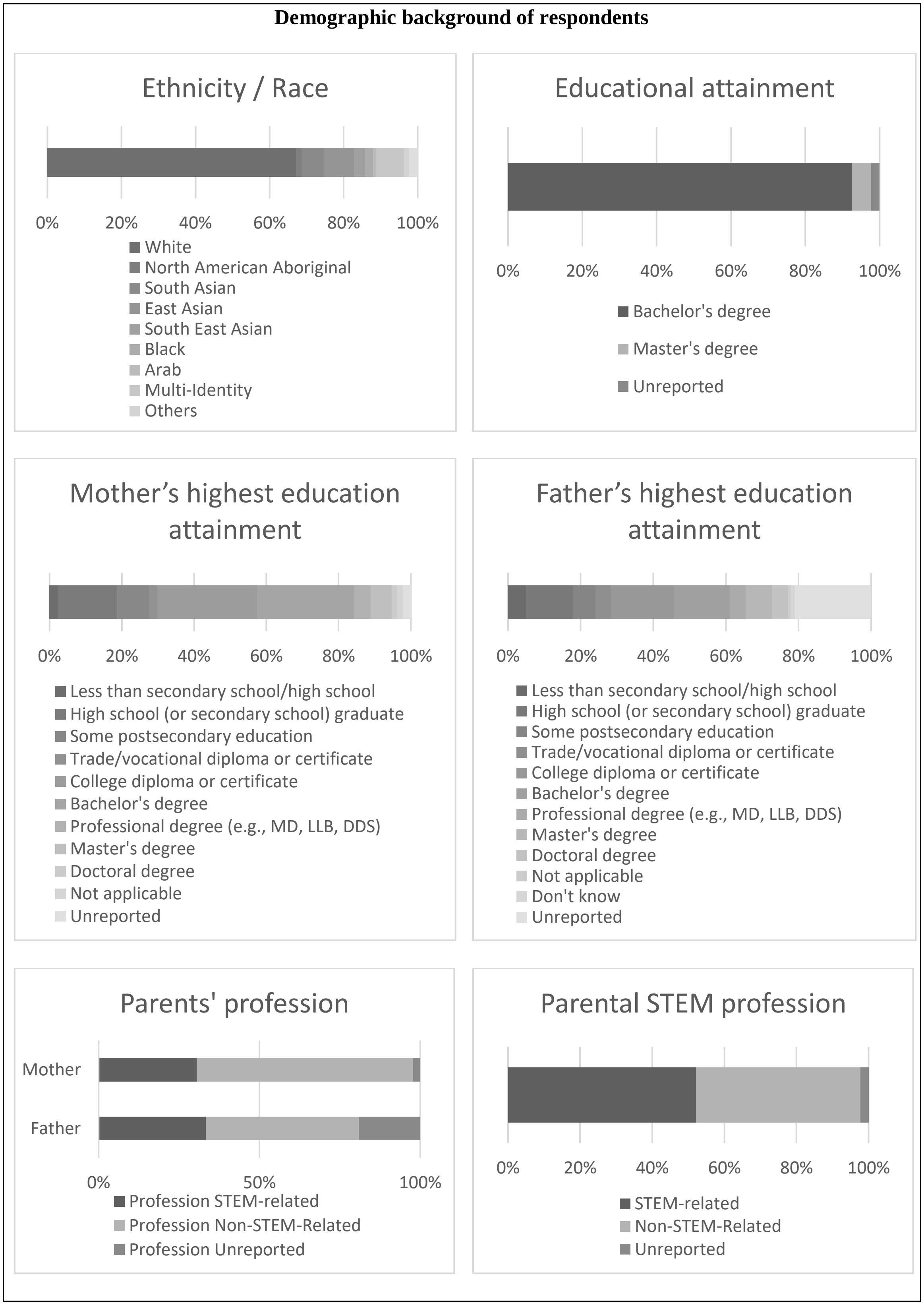

Figure 2. Demographic Background of Respondents (cont.)

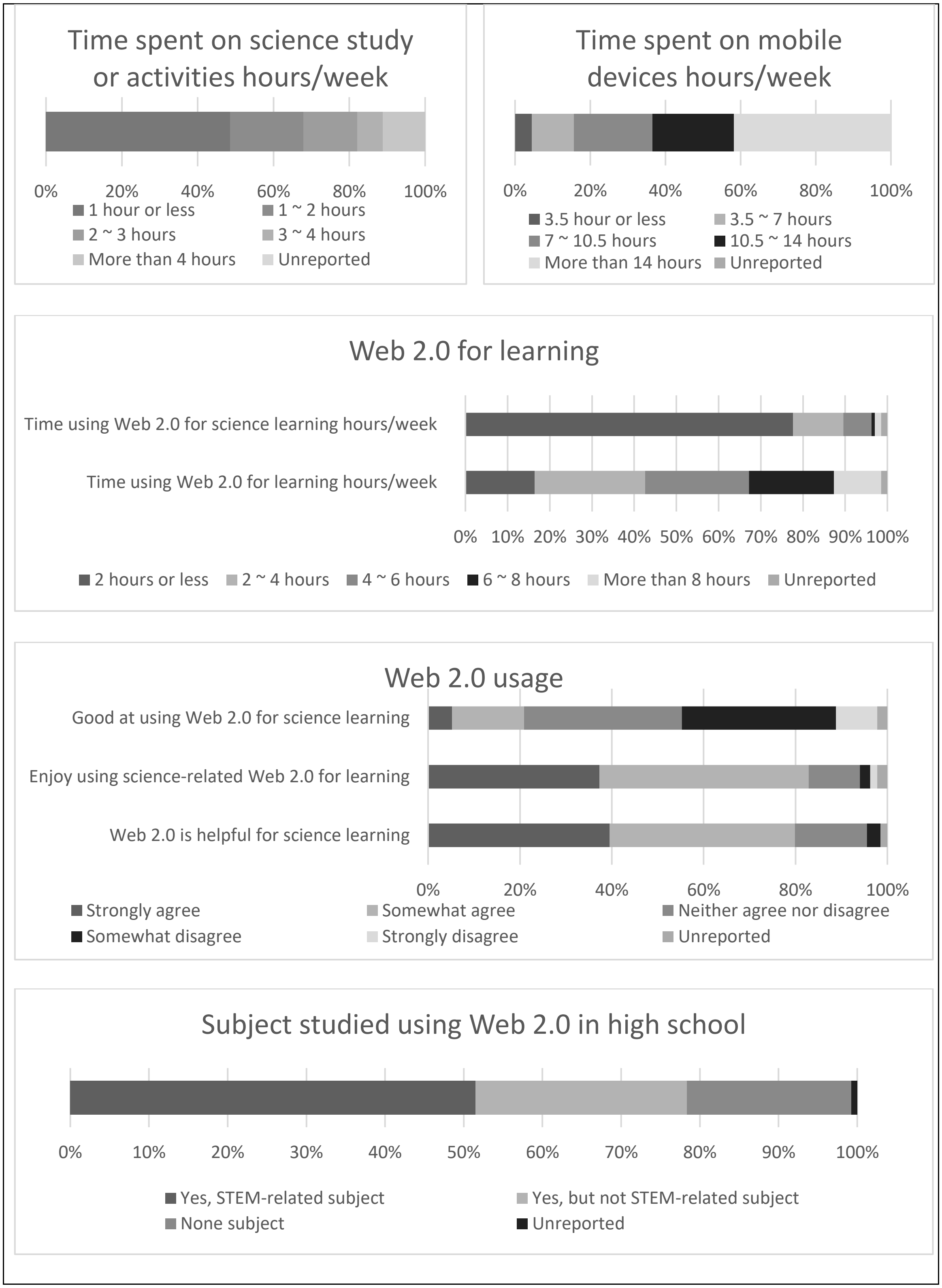

Figure 3. Science and Web 2.0 Learning and Usage Responses

Instrument Validation: Principal Component Analysis for Likert-Scale Items

The following section is a validation process of the Likert-scale items in my instrument, which developed to quantitatively measure pre-service teachers' motivations, attitudes, self-efficacy and aspirations towards science. Also, briefly discussed are the extracted factors and the items included and/or excluded as a result of the validation.

Inter-item Correlations for Multicollinearity and Correlation Examination.

I used IBM SPSS Statistics 25 to do the principal component analysis for each category in science affects. First, a correlation matrix (a matrix of Pearson correlations) table was created for each category (e.g., science attitude, Web 2.0 motivation) which included every item in the category. I removed the items which showed low correlation (< 0.3) (Field, 2013, p. 685) in the *R*-matrixes, and paid careful attention to the items above 0.8 in case of multicollinearity (Gujarati, 2003). Multicollinearity was identified by the determinant of the correlation matrix; a determinant value greater than 0.00001 indicated there was no multicollinearity (Field, 2013, pp. 684). Under these principles, 6 items from the science and 12 items from Web 2.0 were removed before factor analysis as shown in Table 5.

Table 5

The Remaining and Removed Items After Correlation Coefficient Analysis

Category	Remaining Items Order Number[2]	Removed Items Order Number[2]
Science Motivation	Q2, Q3, Q5 to Q8	Q4, Q9
Science Self-Efficacy	Q10, Q11, Q12, Q14 to Q21	Q13, Q22
Science Attitude	Q23, Q24, Q25, Q27 to Q32	Q26
Science Aspiration	Q33, Q35 to Q41	Q34
Web 2.0 Attitude[1]		Q52, Q53, Q54, Q55
Web 2.0 Motivation[1]		Q56, Q57, Q58
Web 2.0 Self-Efficacy[1]		Q59, Q60

Category	Remaining Items Order Number[2]	Removed Items Order Number[2]
Web 2.0 Aspiration[1]		Q61, Q62, Q63

1. All Web 2.0 questions were removed because of low correlation coefficients, maybe because of the sample size;

2. “Q” is the abbreviation of "question", which represents the number of questions in the original questionnaire.

Measures of Sample Adequacy (KMO & Bartlett’s Test).

In order to examine the sample adequacy, I applied the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (Kaiser, 1970) and Bartlett’s test of sphericity on the remaining items.

The KMO test is used to measure if coherent factors can be spotted for factor analysis. It indicates if factors exist among the variables (single or multiple items). The KMO statistic values (between 0 and 1) represent the proportion of variance in the variables (Field, 2013, p. 684); the higher the value, the more reliable the correlations between the paired items, and the more suitable the data is to apply factor analysis. While there is no convincing law, Kaiser (1974) suggested that an adequate value should be greater than 0.5; Field(Field, 2013), George and Mallery(2011), and Hutcheson and Sofroniou (1999) and others provided the “rules of thumb” as: marvelous value > 0.9, meritorious value > 0.8, middling value > 0.7, mediocre value > 0.6, miserable value > 0.5, and unacceptable value < 0.5. As for all the four science categories, the KMO values outmatched 0.5; all the items were adequate for a factor analysis.

Bartlett’s test of sphericity is applied to test the correlation between variables in the observed correlation matrix which differ from an identity matrix significantly (Bartlett, 1951); that is, to test whether each variable is independent. To appropriately use factor analysis, Bartlett’s test should reject the original hypothesis, which means the value should be significant (*p* < .05)(Bartlett, 1951; Field, 2013, p. 685). All our Bartlett's tests of sphericity for all the four science categories indicated that the sampling size was large enough for factor analysis.

Principal Component Analysis: Communality.

To further determine the common variance, a principal component analysis (PCA) procedure was carried out before extraction. As the PCA assumes that the variance is common within a variable, the communality reflects the fraction of the common variance (Field, 2013, p. 697). The four items whose communality values were lower than 0.5 were removed; item 41 was also removed because it was not relevant to the category. In total, 10 items were removed prior to extraction as in Table 6.

Table 6

The Remaining and Removed Items Communality Check (Principal Component Analysis)

Category	Remaining Items	Removed Items
Science Motivation	Q2, Q3, Q5 to Q8	
Science Self-Efficacy	Q10, Q11, Q12, Q16 to Q21	Q14, Q15
Science Attitude	Q23, Q24, Q25, Q27, Q29, Q30, Q32	Q28, Q31
Science Aspiration	Q33, Q35 to Q40	Q41

After removing the 11 items, the KMO measure and Bartlett's test of sphericity were repeated to double check the sample adequacy of the remaining 29 items. All the four science categories passed the KMO and Bartlett reruns. A second run of principal component analyses was also applied. All remaining items showed high communalities. Thus, the remaining 29 items were appropriate for factor extraction.

Factor Extraction: Factor Retention Criteria and Factor Rotation.

To determine the number of factors retaining, a principle for factor extraction eigenvalues had to be determined. Very commonly used criterions in PCA include Kaiser's "eigenvalues greater than one" rule (Kaiser, 1960), Joliffe's "eigenvalues greater than 0.7” criterion (Jolliffe, 2002, p. 115), Cattell’s visual inspection of a scree plot (Cattell, 1966) and others (Plonsky & Gonulal, 2015; Puvirajah, Verma, Li, & Martin-Hansen, 2015). I used Kaiser-1 and scree plot criterions together to extract the retained numbers of factors.

To gain more interpretable solutions for factors, a factor rotation process was run through SPSS. A rotation could be either orthogonal or oblique: orthogonal rotations are applicable for factors which may be uncorrelated, and oblique rotations are suited to correlated factors. Since I built the survey items based on independent subcategories in each category, the appropriate rotation for this research is the Varimax (a kind of orthogonal rotation) rotation.

Synthesizing the Kaiser-1 criterion, scree plot and factor rotation results, I extracted two components for science motivation and science attitude, and one component for science self-efficacy and science aspiration.

Factor Extraction: Factor Loadings and Reliability Analysis.

In Table 7, I report the extracted factors for each category and responding factor loadings; all the loadings were greater than 0.561, which was significant(Stevens, 2002). We also examined the internal consistency within the extracted factors by Cronbach’s alpha reliability analysis (Cronbach, 1951). George and Mallery (2003) judged the Cronbach’s alpha value criteria as: a > 0.9 (Excellent), a > 0.8 (Good), a > 0.7 (Acceptable), a > 0.6 (Questionable), a > 0.5(Poor), and a < 0.5 (Unacceptable). All the factors’ values were above “acceptable” ranges, as shown in Table 7:

Table 7

Summary of Items, Corresponding Factor Loading and Communality Associated with Each Category

Item Order	**Item**	**Factor Loading**[2 3]	**Communality**
Category 1: Science Motivation,			
a =. 734 (acceptable); Determinant = .111; KMO = .706 (good), df =15, Sig. = .000, Eigenvalue > 1			
Factor 1: Goal-orientated Motivation			
8	In science classes/courses, I would do my best to perform well.	.890	.817
6	In science classes/courses, I have always aimed for and worked for high marks.	.857	.740
7	When I was faced with difficulties in understanding science, I tried to use a variety of ways to overcome these difficulties.	.824	.689
Factor 2: Self-Determination Motivation			
3 (r)[1]	If I had a choice, I would not study science. (r)	.862	.770
2	I like solving challenging science problems.	.817	.677
5 (r)	I only took minimally necessary number of science classes for high school graduation. (r)	.790	.629
Category 2: Science Self-Efficacy,			
a = .926 (excellent); Determinant = .002; KMO=. 915 (superb), df = 36, Sig. = .000, Eigenvalue > 1			
16	I believe I can use clear diagrams to express science ideas.	.826	.682
19	I believe I am able to apply the science knowledge to my other academic work when appropriate.	.823	.678
11	I believe I can understand most of the science concepts taught in a science class.	.819	.671
20	I believe I can understand new science knowledge and make logical connections to my previous knowledge.	.818	.669
10	I believe I can understand and apply the science terminologies correctly.	.813	.661
17	I believe I can make clear and audience-friendly science presentations.	.789	.622
12	I believe I can identify key information in science problems.	.774	.599
18	I believe I can use formulae and SI units to express science knowledge (e.g., force analysis, chemical reaction, genetic formula; mass, time, length, etc.).	.768	.589

Item Order	Item	Factor Loading[2 3]	Communality
21	I believe I can explain phenomenon and solve problems in real life using my science knowledge.	.757	.573
Category 3: Science Attitude,			
a = .834 (good); Determinant = .052; KMO = .784 (good), df = 21, Sig. = .000, Eigenvalue > 1			
Factor 1: Personal Engagement			
29	I often talk about science questions with my family or friends.	.839	.705
27	I liked learning science in school.	.782	.654
25	I find participating in science (learning and doing) activities interesting.	.761	.717
30	I like to observe natural/scientific phenomena in my daily life.	.758	.631
32	I try to frequently apply science knowledge in real life (e.g. cooking, gardening, sporting, etc.)	.707	.535
Factor 2: Value to society			
23	Science is important to society.	.900	.814
24	Science is helpful for improving people's daily life.	.800	.735
Category 4: Science Aspiration,			
a = .911 (excellent); Determinant = .010; KMO = .885 (great), df = 21, Sig. = .000, Eigenvalue > 1			
38	I will keep learning science even if it was not required in my profession.	.889	.790
39	I would seriously consider taking some/further science-related courses so that I could be certificated/endorsed in a specific science field.	.861	.742
40	I will keep using science even if my work is not related to science.	.801	.641
37	I plan on taking at least one science-related course from a post-secondary institution.	.798	.637
36	I plan on enrolling in a science-related post-secondary program.	.788	.621
33	I plan to participate in science-related formal professional development activities or courses in the near future that are not a required part of the program.	.781	.610

Item Order	Item	Factor Loading[2 3]	Communality
35	I plan to participate in informal science-related activities outside of my formal certification program (e.g. robotics clubs, science museums, maker spaces).	.735	.540

Note:
1. r — negatively worded item that was reverse coded for analysis;
2. Variables have been descending reordered by their factor loading values;
3. Category 1 & 3 present VARIMAX-rotated loading values, category 2 & 4 present unrotated loading values.

Summary and Discussion of Principal Component Analysis.

Although WSSWAA instrument was designed by the research team to meet the research purpose, however, the validation process is indispensable. Before data analysis, the instrument should be examined to determine if the scale questions are valid and reliable. A principal component analysis together with Cronbach's alpha construct were applied to meet four purposes: eliminate poorly-correlated and multicollinear items, determine if items and sample size are adequate for factor analysis, remove low communality items, and extract factors. After the principal component analysis, 29 items were kept and classified into four categories: science motivation, science self-efficacy, science attitude, and science aspiration; none of Web 2.0 scale item passed the factor analysis, hence the original 22 Likert-scale items were excluded from further analysis. In sum, six factors were extracted as shown in Table 8, which matches the theoretical models and proposed factors.

Table 8

Summary of Factors Extracted from Science Scale Items

Category/Factor	Number of Items	*a*[1]	Determinant	KMO[2]	*df*	*Sig.*
Science Motivation (*Factor 1*)	6	0.734	0.111	0.706	15	0.000
Factor 1.1: Goal-oriented	*3*					

Category/Factor	Number of Items	a^1	Determinant	KMO[2]	*df*	*Sig.*
Factor 1.2: Self-determination	*3*					
Science Self-efficacy (*Factor 2*)	9	0.926	0.002	0.915	36	0.000
Science Attitude (*Factor 3*)	7	0.834	0.052	0.784	21	0.000
Factor 3.1: Personal Engagement	*5*					
Factor 3.2: Value to Society	*2*					
Science Aspiration (*Factor 4*)	7	0.911	0.010	0.885	21	0.000

Note:

1. Cronbach's alpha value criteria: $a > 0.9$ (Excellent), $a > 0.8$ (Good), $a > 0.7$ (Acceptable);
2. KMO value criteria: KMO > 0.9 (marvelous), KMO > 0.8 (meritorious), KMO > 0.7 (middling).

Descriptive Statistics of Likert-Scale Items

Table 9 to Table 12 present means, medians and standard deviations of scale survey items by science categories and inner factors. The responses to Likert-scale questions were re-coded as scale variables: Strongly agree = 5, Somewhat agree = 4, Neither agree nor disagree = 3, Somewhat disagree = 2, Strongly disagree = 1. Also, the reversed worded questions were re-coded to the form of larger numbers representing more positive opinions.

Science Motivation.

All median values for science motivation questions (except item 6, *median* = 5) were 4, while means ranged from 3.21 to 4.34, which indicate the BEd students had positive motivations towards science (Table 9). Factor 1.1 questions (Q6, 7, 8) display standard deviations less than one, which means that the responses were distributed closely, while *factor 1.2* questions (Q2, 3, 5) revealed more open distributions, especially for *item 5*, which reflected students' different opinions in choosing extra science classes in high school. For the *factor 1, goal-oriented motivation* (*median* = 4.33, *mean* = 4.19, *SD* = 0.94), the high mean, median, and standard deviation values indicate that the participants have a high science motivation related to a goal. For the *factor 2, self-determination motivation* (*median* = 4.00, *mean* = 3.33, *SD* = 1.44), the mean and median values are lower than *motivation factor 1* (but still higher than a neutral value); the case suggests that the participants have high science motivation related to self-determination, however, this type of motivation is lower than goal-oriented motivation.

Table 9

Descriptive Statistics for Science Motivation

Item Order	**Item**	**Median**	***Mean***	***Std. Deviation***
	Factor 1: Goal-orientated Motivation			
6	In science classes/courses, I have always aimed for and worked for high marks.	5	4.34	.966
7	When I was faced with difficulties in understanding science, I tried to use a variety of ways to overcome these difficulties.	4	3.94	.979
8	In science classes/courses, I would do my best to perform well.	4	4.31	.886
	Factor 2: Self-Determination Motivation			
2	I like solving challenging science problems.	4	3.29	1.162
3r	If I had a choice, I would not study science.	4	3.49	1.429
5r	I only took minimally necessary number of science classes for high school graduation.	4	3.21	1.743

Note: r — negatively worded item that was reverse coded for analysis

Science Self-Efficacy.

All median values for science self-efficacy questions, except item 18 (median = 3), were 4, while means ranged from 3.01 to 3.99, which indicates the BEd students reflected positive self-efficacy towards science (Table 10). Questions 10, 11, 12, 16, 17, 19, and 21 display standard deviations less than one or very close to one, which means that the responses were distributed closely, while question 18 revealed more open distribution, which indicates that students expressed different levels of confidence in using science formulas and SI units.

Table 10

Descriptive Statistics for Science Self-Efficacy

Item No.	Item	Median	*Mean*	*Std. Deviation*
10	I believe I can understand and apply the science terminologies correctly.	4	3.63	1.101
11	I believe I can understand most of the science concepts taught in a science class.	4	3.87	.992
12	I believe I can identify key information in science problems.	4	3.99	.965
16	I believe I can use clear diagrams to express science ideas.	4	3.86	1.070
17	I believe I can make clear and audience-friendly science presentations.	4	3.96	1.043
18	I believe I can use formulae and SI units to express science knowledge (e.g., force analysis, chemical reaction, genetic formula; mass, time, length, etc.).	3	3.01	1.427
19	I believe I am able to apply the science knowledge to my other academic work when appropriate.	4	3.56	1.219
20	I believe I can understand new science knowledge and make logical connections to my previous knowledge.	4	3.83	.977
21	I believe I can explain phenomenon and solve problems in real life using my science knowledge.	4	3.75	1.120

Science Attitude.

Table 11 presents median, mean and standard deviation values for science self-efficacy questions. For *factor 3.1*, all median values except item 29 (median = 3) were 4, while means ranged from 3.79 to 4.22, which indicate the BEd students reflected positive attitudes towards science personal engagement, except item 29 (median = 3, mean = 2.93); standard deviations distribute closely for items 25, 30, 32, indicating that the responses were close to average values, and items 27 and 29 showed more differences. Examination of item 29 indicates that although pre-service teachers have positive attitudes towards science, they are less likely to talk about science in their daily life. For factor 3.2, median values were both 5, while means ranged from 4.63 to 4.82, which indicate the BEd students reflected very positive attitudes towards science from the perspective of the value to society. Questions 23 and 24 display standard deviations less than 0.7, which means that the responses were distributed closely. For *factor 1, personal engagement* (*median* = 3.80, *mean* = 3.77, *SD* = 1.13), the high mean, median, and standard deviation values indicate that the participants have positive science attitudes related to personal engagement. The results suggest that the participants have positive attitudes towards science in both factors, but the *factor 2, value to society* (*median* = 5.00, *mean* = 4.73, *SD* = 0.53), has higher mean, higher median, and lower standard deviation values than *factor 1*, indicating that participants highly recognize the value science plays in society.

Table 11

Descriptive Statistics for Science Attitude

Item No.	**Item**	**Median**	***Mean***	***Std. Deviation***
	Factor 1: Personal Engagement			
25	I find participating in science (learning and doing) activities interesting.	4	4.22	.955
27	I liked learning science in school.	4	3.79	1.281
29	I often talk about science questions with my family or friends.	3	2.93	1.316
30	I like to observe natural/scientific phenomena in my daily life.	4	3.93	1.091
32	I try to frequently apply science knowledge in real life (e.g. cooking, gardening, sporting, etc.)	4	3.96	1.014

Item No.	Item	Median	Mean	Std. Deviation
	Factor 2: Value to Society			
23	Science is important to society.	5	4.82	.422
24	Science is helpful for improving people's daily life.	5	4.63	.644

Science Aspiration.

Table 12 shows that median values for science aspiration questions ranged from 1.5 to 4, while means ranged from 2.25 to 3.50, which indicate the BEd students' aspiration for science varied. All questions revealed standard deviations of more than one, indicating that students expressed different aspirations towards science. Concretely, participants showed positive opinions in further non-formal or optional learning and using science in the future; however, they were slightly negative tendency to keep learning science in formal or professional forms.

Table 12

Descriptive Statistics for Science Aspiration

Item No.	Item	Median	Mean	Std. Deviation
33	I plan to participate in science-related formal professional development activities or courses in the near future that are not a required part of the program.	3	3.22	1.311
35	I plan to participate in informal science-related activities outside of my formal certification program. (e.g. robotics clubs, science museums, maker spaces)	3	2.96	1.271
36	I plan on enrolling in a science-related post-secondary program.	1.5	2.25	1.49
37	I plan on taking at least one science-related course from a post-secondary institution.	3	3.01	1.539
38	I will keep learning science even if it was not required in my profession.	4	3.25	1.438

Item No.	Item	Median	Mean	Std. Deviation
39	I would seriously consider taking some/further science-related courses so that I could be certificated/endorsed in a specific science field.	3	2.89	1.449
40	I will keep using science even if my work is not related to science.	4	3.50	1.319

Summary and Discussion of Descriptive Statistics of Scale Items.

The purpose of analyzing descriptive statistics for Likert-scale items is to investigate the participants' overall perceptions about science motivation, self-efficacy, attitude and aspiration. By analyzing the medians, means, and standard deviations for each science category as shown below in Table 13, the following conclusions can be made:

Pre-service teachers who participated in the study generally scored high marks in all four categories in science (*median* = 3.82, *mean* = 3.64, *SD* = 1.16), which indicate that they have overall high motivation (*median* = 4.17, *mean* = 3.77, *SD* = 1.19), high self-efficacy (*median* = 3.89, *mean* = 3.72, *SD* = 1.10), positive attitude (*median* = 4.15, *mean* = 4.04, *SD* = 0.96), and neutral aspiration (*median* = 3.08, *mean* = 3.02, *SD* = 1.40) towards science.

When the (sub)categories are compared among each other, attitude factor 2: *Value to Society* (*median* = 5.00, *mean* = 4.73, *SD* = 0.53) shows the highest median, highest mean and lowest standard deviation values among categories, indicating that participants strongly recognize the value science plays in society without much discrepancy. The next highest scoring factor was the motivation factor 1: *Goal-oriented Motivation* (*median* = 4.33, *mean* = 4.19, *SD* = 0.94), which reveals that participants have high motivation for goals related to science and related activities. The lowest score among all the categories belongs to science aspiration, the mean is very close to 3 (neither agree nor disagree), showing the pre-service teachers have neutral tendency of embracing a science-related career; however, a higher divergence also exists (*SD* = 1.40).

A noteworthy detail is the difference between the two factors in motivation and attitude categories. Although both motivation and attitude have high values, the values belonging to their sub-categories have clear differences. Motivation *factor 2*, *self-determination* scored lower value compared to not only motivation *factor 1*, *goal-oriented motivation*, but self-efficacy and two attitude factors as well. This suggests that participants have less self-determination motivation compared to other categories. A possible reason is that some items include information about concrete practice (e.g., Q5: I like solving challenging science problems) rather than abstract ideas, so that participants responded referring to their previous operation rather than according to their thoughts.

Table 13

Summary of Descriptive Statistics for Science Likert-Scale Items

Category	**Factor**	***Median***	***Mean***	***SD***
Motivation		4.17	3.77	1.19
Factor 1	*Goal-orientated Motivation*	*4.33*	*4.19*	*0.94*
Factor 2	*Self-Determination Motivation*	*4.00*	*3.33*	***1.44***
Self-Efficacy		3.89	3.72	1.10
Attitude		4.15	4.04	0.96
Factor 1	*Personal Engagement*	*3.80*	*3.77*	*1.13*
Factor 2	*Value to Society*	***5.00***	***4.73***	***0.53***
Aspiration		3.08	**3.02**	1.40
Average		3.82	3.64	1.16

Multiple Linear Regression

Investigating Possible Demographic, Science, and Web 2.0 Predictors Variables.

Since there are more than 20 potential predictor variables (see Table 3 and Table 4) that can be possible used to predict a participant's science motivation, attitude, self-efficacy and aspiration scores, which is too complicated for further analysis, a multi-linear regression method was first applied to investigate if these potential variables really predict the science scores. The β scores in these exploration results do not stand for real coefficients in models, and only the variables that have non-zero values will be further tested to investigate if they have significant impacts on science scores.

Demographic Predictor Variables.

Stepwise multiple linear regression was performed to investigate if the science scores are predicted by demographic predictor variables shown in Table 3. Twelve variables were explored in this process: (a) gender, (b) grade, (c) program, (d) age, (e) ethnicity or race, (f) education attainment, (g) educational background, (h) whether a participant had a science-related post-secondary major, (i) specialty area, (j) teaching option, (k) parental education attainments, and (l) parental professions.

The results entered two variables as major predictors for science motivation and aspiration question scores: (g) educational background, and (h) whether a participant had a science-related post-secondary major. For science self-efficacy and attitude, the result showed two predictors, (g) educational background and (j) teaching option, were entered. The detailed summary is shown in Table 14.

Table 14

Summary of Entered Demographic Predictors in Multi-Regression Analysis for Science Scores

Model	R Square	*df*	*ß*	*Sig.*
Science Motivation	0.569	2		
A science-related post-secondary major			-.303	0.000
STEM-related educational background			-.502	0.015
Science Self-Efficacy	0.515	2		
STEM-related educational background			-.528	0.000
Teaching Option			-.268	0.015
Science Attitude	0.382	2		
STEM-related educational background			-.412	0.001
Teaching Option			-.280	0.024
Science Aspiration	0.605	2		
A science-related post-secondary major			-.470	0.000
STEM-related educational background			-.363	0.003

In summary, three potential variables, (g) educational background, (h) whether a participant has a science-related post-secondary major, and (j) teaching option, will be tested to investigate if they predict participants' science scores.

Science and Web 2.0 Learning and Usage Predictor Variables.

Stepwise multiple linear regressions were performed to investigate if the science scores are predicted by science and Web 2.0 learning and usage variables showed in Table 15. Eight variables were explored in this process: (a) time spending on science learning and activities, (b) time spending on mobile devices, (c) time spending on Web 2.0 for learning, (d) time using Web 2.0 for science learning, (e) how much a participant thinks Web 2.0 is helpful for science learning, (f) how much a participant enjoys using science-related Web 2.0 for learning, (g) how much a participant thinks himself/herself as being good at using Web 2.0 for science learning, and (h) what subject a participant use Web 2.0 to study in high school.

The results showed one variable as major predictor for *Science Motivation* question scores: (a) time spending on science learning and activities. For Science Self-efficacy score, the results showed 5 predictors; (a) time spending on science learning and activities, (c) time using Web 2.0 for learning, (d) time using Web 2.0 for science learning, (f) how much a participant enjoys using science-related Web 2.0 for learning, and (g) how much a participant think himself/herself good at using Web 2.0 for science learning. Science Attitude result indicated that (a) time spending on science learning and activities and, (e) how much a participant think Web 2.0 is helpful for science learning. Science Aspiration is predicted by (a) science time, (d) time using Web 2.0 for science learning, and (f) how much a participant enjoys using science-related Web 2.0 for learning. The detailed summary is shown in Table 15.

Table 15

Summary of Entered Science and Web 2.0 Learning and Usage Predictors in Multi-Regression Analysis for Science Scores

Model	**R Square**	***df***	***ß***	***Sig.***
Science Motivation	0.270	1		
Time spending on science learning and activities			-1.818	0.000
Science Self-Efficacy	0.378	5		
Time spending on science learning and activities			-2.478	0.000
Enjoys using science-related Web 2.0 for learning			1.861	0.007
Time using Web 2.0 for learning			1.571	0.001
Time using Web 2.0 for science learning			-2.095	0.010
Good at using Web 2.0 for science learning			1.212	0.030
Science Attitude	0.297	2		

Model	**R Square**	***df***	***β***	***Sig.***
Time spending on science learning and activities			-1.749	0.000
Think Web 2.0 is helpful for science learning			1.360	0.005
Science Aspiration	0.459	3		
Time spending on science learning and activities			-3.142	0.000
Time using Web 2.0 for science learning			-1.857	0.011
Enjoys using science-related Web 2.0 for learning			1.317	0.038

In summary, six potential predictor variables, (a) time spending on science learning and activities, (c) time using Web 2.0 for learning, (d) time using Web 2.0 for science learning, (e) how much a participant thinks Web 2.0 is helpful for science learning, (f) how much a participant enjoys using science-related Web 2.0 for learning, and (g) how much a participant thinks himself/herself being good at using Web 2.0 for science learning, will be tested to investigate if they really predict participants' science scores.

Investigating Possible Category Scores as Predictors of Science Scores.

Science Motivation.

A stepwise multiple linear regression was performed to investigate if science motivation is significantly predicted by science self-efficacy, attitude and aspiration. The results indicated that a significant regression equation was found ($F(2,131) = 117.28$, $p <$ 0.001), with an R^2 of 0.642. Science self-efficacy ($\beta = 0.469$, $p < 0.001$) and aspiration ($\beta = 0.401$, $p < 0.001$) were significant predictors of science motivation; science attitude did not significantly improve prediction ($p = 0.073$). Science motivation, self-efficacy, attitude and aspiration scores are coded as 1 = Strongly disagree, 2 = Somewhat disagree, 3 = Neither agree nor disagree, 4 = Somewhat agree, and 5 = Strongly agree. The final predictive model was:

Motivation Score = 0.469 (Self-Efficacy Score) + 0.401 (Aspiration Score)

Science Self-Efficacy.

A stepwise multiple linear regression was performed to investigate if science self-efficacy is significantly predicted by science motivation, attitude, and aspiration. The results indicated that a significant regression equation was found ($F(2,131) = 129.632$, $p < 0.001$), with an R^2 of 0.664. Both science attitude ($\beta = 0.468$, $p < 0.001$) and motivation ($\beta = 0.411$, $p < 0.001$) were significant predictors of science self-efficacy. Science aspiration did not significantly improve prediction ($p = .236$). Science motivation, self-efficacy, attitude and aspiration scores are coded as 1 = Strongly disagree, 2 = Somewhat disagree, 3 = Neither agree nor disagree, 4 = Somewhat agree, and 5 = Strongly agree. The final predictive model was:

Self-Efficacy Score = 0.468 (Attitude Score) + 0.411 (Motivation Score)

Science Attitude.

A stepwise multiple linear regression was performed to investigate if science attitude is significantly predicted by science self-efficacy, motivation and aspiration. The results indicated that a significant regression equation was found ($F(2,131) = 145.906$, $p < 0.001$), with an R^2 of 0.690. Science self-efficacy ($\beta = 0.448$, $p < 0.001$), aspiration ($\beta = 0.456$, $p < 0.001$) were significant predictors of science attitude. Science motivation did not significantly improve prediction ($p = .073$). Science motivation, self-efficacy, attitude and aspiration scores are coded as 1 = Strongly disagree, 2 = Somewhat disagree, 3 =

Neither agree nor disagree, 4 = Somewhat agree, and 5 = Strongly agree. The final predictive model was:

Attitude Score = 0.456 (Aspiration Score) + 0.448 (Self-Efficacy Score)

Science Aspiration.

A stepwise multiple linear regression was performed to investigate if science aspiration is significantly predicted by science self-efficacy, attitude, and aspiration. The results indicated that a significant regression equation was found ($F(2,131) = 121.832$, $p < 0.001$), with an R^2 of 0.650. Both science attitude ($\beta = .504$, $p < 0.001$) and motivation ($\beta = .364$, $p < 0.001$) were significant predictors of science aspiration. Science self-efficacy did not significantly improve prediction ($p = .236$). Science motivation, self-efficacy, attitude and aspiration scores are coded as 1 = Strongly disagree, 2 = Somewhat disagree, 3 = Neither agree nor disagree, 4 = Somewhat agree, and 5 = Strongly agree. The final predictive model was:

Aspiration Score = 0.504 (Attitude Score) + 0.364 (Motivation Score)

Summary and Discussion of Multi-Linear Regression.

The two purposes of multi-linear regression analysis are to explore the potential demographic, science learning and/or Web 2.0 utilizing variables that predict science question scores, and to predict the science motivation/self-efficacy/attitude/aspiration question scores using other three category question scores.

For the first purpose, R square and β values are used as indicators to sift the demographic and science/Web 2.0 learning/usage variables: three demographic variables and six science/Web 2.0 learning/usage variables are obtained for further analysis. Although variables “educational background” and “whether a participant had a science-related post-secondary major” looks literally similar, the multicollinearity check suggested that the variance inflation factors (VIF) are smaller than 3, which indicated that multicollinearity is not a problem (Field, 2013, p. 343).

For the other purpose, four predictor models are summarized to predict science motivation/self-efficacy/attitude/aspiration question score using science sub-category scores except itself. The relationships, correlation coefficients, and constants in the models are shown in Table 16**Error! Reference source not found.**.

Table 16

Summary of Multi-Linear Regression Models of Science Scores in Each Category

Question Score Category	**Predictor**					
	Correlation Coefficients				Constant	R^2
	Motivation	*Self-Efficacy*	*Attitude*	*Aspiration*		
Motivation	-	0.469	0.401		-	0.642
Self-Efficacy	0.411	-	0.468	-	-	0.664
Attitude	-	0.448	-	0.456	-	0.690
Aspiration	0.364	-	0.504	-	-	0.650

The results display the cross relationship among science motivation, self-efficacy, attitude, and aspiration scores. Four stepwise multi-linear regression models can explain over 64% of variances (motivation – 64.2%, self-efficacy – 66.4%, attitude – 69.0%, aspiration – 65.0%).

Specifically, motivation is predicted by two predictors, indicating that self-efficacy and aspiration had significant positive regression with motivation; in other words, a student with higher self-efficacy and aspiration towards science is expected to have a higher motivation towards science; however, science attitude does not contribute to the model. Self-efficacy is predicted by two predictors, indicating that attitude and motivation had significant positive regression with self-efficacy; in other words, a student with higher attitude and motivation towards science is expected to have a higher self-efficacy towards science, however, science aspiration does not contribute to the model. Attitude is predicted by two predictors, indicating that self-efficacy and aspiration had significant positive regression with attitude; in other words, a student with higher self-efficacy and aspiration is expected to have a higher attitude towards science; however, science motivation does not contribute to the model. Aspiration is predicted by two predictors, indicating that attitude and motivation had significant positive regression with aspiration; in other words, a student with higher attitude and motivation towards science is expected to have a higher aspiration towards science; but science self-efficacy does not contribute to the model.

A noteworthy detail is that although the four categories can cross predict others, some predictors are not related to each other. Self-efficacy and aspiration only predict two models excluding themselves; they do not predict each other. Motivation and attitude only predict two models excluding themselves; they do not predict each other either. The predictive relationships among the four categories is shown as Figure 4.

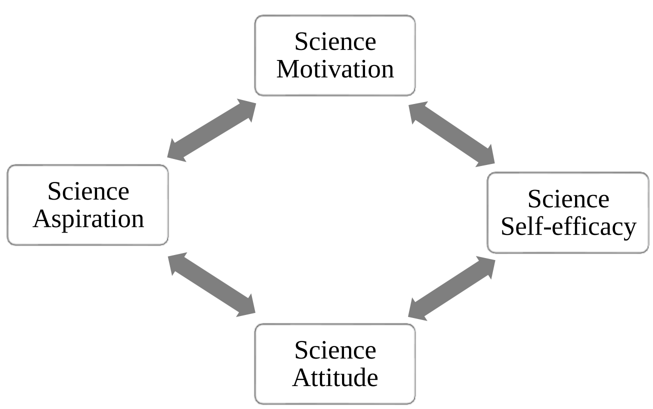

Figure 4. Predictor Relationship between Science Motivation, Self-efficacy, Attitude and Aspiration

Independent Samples T-Test to Compare Means

Independent samples *t*-tests were applied to examine if there are significant differences between two unpaired options. To investigate the possible difference between different variables, six predictor variables were examined using independent *t*-tests. The six variables examined using multi-linear regression are (see page 63): (a) gender (males, females), (b) grade (first year, second year), (c) time spent on learning about science (less than one hour per week, more than one hour per week), (d) educational backgrounds (STEM-related, not STEM related), (e) a science-related post-secondary major (yes, no), and (f) teaching option (STEM-related, not STEM-related), on science motivation/self-efficacy/attitude/aspiration question scores. The results are shown in Table 17 to Table *20*.

Science Motivation.

Table 17

T-test Results Comparing Variables on Science Motivation Question Scores

Variable	Option	Mean	*SD*	*t*	*df*	*p*
Gender	Female	22.56	4.90	-.053	126	.957
	Male	22.62	4.82			
Grade	First-year	22.14	4.80	-3.004	132	**.003**
	Second-year	26.00	3.54			
Science study/activity	>=1h	25.00	3.72	6.991	132	**.000**
time	<1h	20.00	4.53			
Educational	STEM-related	26.43	2.77	9.263	123.01	**.000**
background	Not STEM-related	20.57	4.42			
A science-related post-	Yes	26.71	2.57	9.89	120.951	**.000**
secondary major	No	20.64	4.39			
Teaching option	STEM-related	25.51	3.88	4.484	132	**.000**
	Not STEM-related	21.53	4.71			

Independent *t*-tests were conducted to examine differences in motivation question scores, between the paired variables in different variables. The results in Table 17 indicate that:

1. There was no significant difference in motivation question scores between male and female, $t(126) = -0.053$, $p = 0.957$.
2. There was a significant difference in motivation scores between the grades (the year in the program), $t(132) = -3.004$, $p = 0.003$; the result suggests that participants in first year ($M = 22.14$, $SD = 4.80$) scored significantly lower than the second-years ($M = 26.00$, $SD = 3.54$); in other words, the first-years presented lower motivation in science than the second-years.
3. There was a significant difference in motivation scores between the two groups in science study/activity time variable, $t(132) = 6.99$, $p < 0.001$; the result suggests that participants in shorter time (<1h, $M = 20.00$, $SD = 4.53$) scored significantly lower than the longer time group (>=1h, $M = 25.00$, $SD = 3.72$); in other words, the shorter time group presented lower motivation in science than the longer time group.
4. There was a significant difference in motivation scores between the two groups in educational background variable, $t(123.01) = 9.263$, $p < 0.001$; the result suggests that participants in STEM-related educational background group ($M = 26.43$, $SD = 2.77$) scored significantly higher than those in non-STEM-related educational background group ($M = 20.57$, $SD = 4.42$); in other words, the STEM-related group presented higher motivation in science than the non-STEM-related group.
5. There was a significant difference in motivation scores between the two groups in science-related post-secondary majors, $t(120.951) = -9.89$, $p < 0.001$; the result

suggests that participants who have science-related post-secondary majors (*M* = 26.71, *SD* = 2.57) scored significantly higher than those who did not have a science-related major (*M* = 20.64, *SD* = 4.39); in other words, the participants who have science-related post-secondary majors presented higher motivation in science than those who did not have.

6. There was a significant difference in motivation scores between the two groups in teaching option variable, $t(132) = 4.484$, $p < 0.001$; the result suggests that participants in STEM-related teaching option group (*M* = 25.51, *SD* = 3.88) scored significantly higher than those in non-STEM-related teaching option group (*M* = 21.53, *SD* = 4.57); in other words, the STEM-related teaching option participants presented higher motivation in science than the non-STEM-related group.

Science Self-Efficacy.

Table 18

T-test Results Comparing Variables on Science Self-Efficacy Question Scores

Variable	Option	Mean	SD	t	df	p
Gender	Female	32.87	8.09	-1.05	126	.295
	Male	34.65	7.68			
Grade	First-year	32.70	7.68	-2.84	132	**.005**
	Second-year	38.80	8.79			
Science study/activity time	>=1h	37.34	5.09	6.732	104.01	**.000**
	<1h	29.18	8.43			
Educational background	STEM-related	39.41	4.67	8.592	123.32	**.000**
	Not STEM-related	30.21	7.50			

Variable	**Option**	**Mean**	***SD***	***t***	***df***	***p***
A science-related post-secondary major	Yes	39.44	4.18	8.55	125.08	**.000**
	No	30.51	7.72			
Teaching option	STEM-related	38.42	5.86	4.651	132	**.000**
	Not STEM-related	31.61	7.94			

Independent *t*-tests were conducted to examine differences in self-efficacy question scores, between the paired options in different variables. The results in Table 18 indicate that:

1. There was no significant difference in science self-efficacy question scores between genders, $t(126) = -1.05$, $p = 0.295$.
2. There was a significant difference in self-efficacy scores between the grades, $t(132) = -2.84$, $p = 0.005$; the result suggests that participants in first year ($M = 32.70$, $SD = 7.68$) scored significantly lower than the second-years ($M = 38.80$, $SD = 8.79$); in other words, the first-years presented lower self-efficacy in science than the second-years.
3. There was a significant difference in self-efficacy scores between the two groups in science study/activity time variable, $t(104.01) = 6.732$, $p < 0.001$; the result suggests that participants in shorter time (<1h, $M = 29.18$, $SD = 8.43$) scored significantly lower than the longer time group (>=1h, $M = 37.34$, $SD = 5.09$); in other words, the shorter time group presented lower self-efficacy in science than the longer time group.
4. There was a significant difference in self-efficacy scores between the two groups in educational background variable, $t(123.32) = 8.592$, $p < 0.001$; the result suggests that participants in STEM-related educational background group (M =

39.41, *SD* = 4.67) scored significantly higher than the non-STEM-related educational background group (*M* = 30.21, *SD* = 7.50); in other words, the STEM-related group presented higher self-efficacy in science than the non-STEM-related group.

5. There was a significant difference in self-efficacy scores between the two groups in science-related post-secondary majors, $t(125.08) = 8.55$, $p < 0.001$; the result suggests that participants who have science-related post-secondary majors (*M* = 39.44, *SD* = 4.18) scored significantly higher than those who did not have science-related majors (*M* = 30.51, *SD* = 7.72); in other words, the participants who have science-related post-secondary majors presented higher self-efficacy in science than those who did not have a science-related major.
6. There was a significant difference in self-efficacy scores between the two groups in teaching option variable, $t(132) = 4.651$, $p < 0.001$; the result suggests that participants in STEM-related teaching option group (*M* = 38.42, *SD* = 5.86) scored significantly higher than non-STEM-related teaching option group (*M* = 31.61, *SD* = 7.94); in other words, the STEM-related teaching option participants presented higher self-efficacy in science than the non-STEM-related group.

Science Attitude.

Table 19

T-test Results Comparing Variables on Science Attitude Question Scores

Variable	Option	Mean	*SD*	*t*	*df*	*p*
Gender	Female	28.27	5.07	-.165	126	.869
	Male	28.44	4.91			

Variable	Option	Mean	*SD*	*t*	*df*	*p*
Grade	First-year	27.79	4.95	-5.196	25.8	**.000**
	Second-year	32.33	2.89			
Science study/activity	>=1h	30.71	3.76	6.667	132	**.000**
time	<1h	25.74	4.82			
Educational	STEM-related	31.34	3.85	5.603	129	**.000**
background	Not STEM-related	26.68	4.78			
A science-related	Yes	31.95	2.93	7.873	118.676	**.000**
post-secondary major	No	26.56	4.83			
Teaching option	STEM-related	30.83	4.06	3.665	132	**.000**
	Not STEM-related	27.40	4.96			

Independent *t*-tests were conducted to examine differences in attitude question scores, between the paired variables in different variables. The results in Table 19 indicate that:

1. There was no significant difference in science attitude question scores between genders, $t(126) = -0.165$, $p = 0.869$.
2. There was a significant difference in attitude scores between the grades, $t(25.8) = -5.196$, $p < 0.001$; the result suggests that participants in first year ($M = 27.79$, $SD = 4.95$) scored significantly lower than the second-years ($M = 32.33$, $SD = 2.89$); in other words, the first-years presented lower attitude in science than the second-years.
3. There was a significant difference in attitude scores between the two groups in science study/activity time variable, $t(132) = 6.667$, $p < 0.001$; the result suggests that participants in shorter time (<1h, $M = 25.74$, $SD = 4.82$) scored significantly lower than the longer time group (>=1h, $M = 30.71$, $SD = 3.76$); in other words,

the shorter time group presented lower attitude in science than the longer time group.

4. There was a significant difference in attitude scores between the two groups in educational background variable, $t(129) = 5.603$, $p < 0.001$; the result suggests that participants in STEM-related educational background group ($M = 31.34$, $SD = 3.85$) scored significantly higher than non-STEM-related educational background group ($M = 26.68$, $SD = 4.78$); in other words, the STEM-related group presented more positive attitude in science than the non-STEM-related group.
5. There was a significant difference in attitude scores between the two groups in science-related post-secondary majors, $t(118.676) = 7.873$, $p < 0.001$; the result suggests that participants who have science-related post-secondary majors ($M = 31.95$, $SD = 2.93$) scored significantly higher than those who did not have science-related majors ($M = 26.56$, $SD = 4.83$); in other words, the participants who have science-related post-secondary majors presented more positive attitude in science than those who did not have it.
6. There was a significant difference in attitude scores between the two groups in teaching option variable, $t(132) = 3.665$, $p < 0.001$; the result suggests that participants in STEM-related teaching option group ($M = 30.83$, $SD = 4.06$) scored significantly higher than non-STEM-related teaching option group ($M = 27.40$, $SD = 4.96$); in other words, the STEM-related teaching option participants presented more positive attitude in science than the non-STEM-related group.

Science Aspiration.

Table 20

T-test Results Comparing Variables on Science Aspiration Question Scores

Variable	Option	Mean	*SD*	*t*	*df*	*p*
Gender	Female	21.02	7.98	-.316	126	.752
	Male	21.55	7.86			
Grade	First-year	20.62	7.97	-1.87	132	.063
	Second-year	24.67	6.96			
Science study/activity time	>=1h	25.43	6.45	7.92	132	**.000**
	<1h	16.45	6.68			
Educational background	STEM-related	27.52	6.09	8.121	129	**.000**
	Not STEM-related	17.79	6.66			
A science-related post-secondary major	Yes	28.49	4.46	10.826	112.344	**.000**
	No	17.68	6.77			
Teaching option	STEM-related	26.17	7.37	4.76	132	**.000**
	Not STEM-related	19.27	7.36			

Independent *t*-tests were conducted to examine differences in aspiration question scores, between the paired variables in different variables. The results in Table 20 indicated that:

1. There was no significant difference in science aspiration question scores between genders, $t(126) = -0.316$, $p = 0.752$.
2. There was no significant difference in aspiration scores between the grades, $t(132) = -1.87$, $p = 0.063$.
3. There was a significant difference in aspiration scores between the two groups in science study/activity time variable, $t(132) = 7.92$, $p < 0.001$; the result suggests that participants in shorter time (<1h, $M = 16.45$, $SD = 6.68$) scored significantly

lower than the longer time group (>=1h, $M = 25.43$, $SD = 6.45$); in other words, the shorter time group presented lower aspiration in science than the longer time group.

4. There was a significant difference in aspiration scores between the two groups in educational background variable, $t(129) = 8.121$, $p < 0.001$; the result suggests that participants in STEM-related educational background group ($M = 27.52$, $SD = 6.09$) scored significantly higher than non-STEM-related educational background group ($M = 17.79$, $SD = 6.66$); in other words, the STEM-related group presented higher aspiration in science than the non-STEM-related group.

5. There was a significant difference in aspiration scores between the two groups in science-related post-secondary majors, $t(112.344) = 10.826$, $p < 0.001$; the result suggests that participants who have science-related post-secondary majors ($M = 28.49$, $SD = 4.46$) scored significantly higher than those who did not have science-related majors ($M = 17.68$, $SD = 6.77$); in other words, the participants who have science-related post-secondary majors presented higher aspiration in science than those who did not have in.

6. There was a significant difference in aspiration scores between the two groups in teaching option variable, $t(132) = 4.76$, $p < 0.001$; the result suggests that participants in STEM-related teaching option group ($M = 26.17$, $SD = 7.37$) scored significantly higher than non-STEM-related teaching option group ($M = 19.27$, $SD = 7.32$); in other words, the STEM-related teaching option participants presented more positive aspiration in science than the non-STEM-related group.

Summary and Discussion of Independent *T*-Test.

The purpose of independent *t*-test analysis is to investigate the possible difference question score between group of people. In this part, only the variables containing two ways were measured. More specifically, I aim to compare two means which come from a pair of entities in a factor. Six variables were examined using independent sample *t*-tests to determine whether or not the means of science question scores are significantly different: gender, grade, time spent on learning about science, educational background, a science-related post-secondary major, and teaching option; significance level equals to 0.05. The results reveal that:

1. Gender does not affect question scores in motivation, self-efficacy, attitude, and aspiration categories.
2. Four variables: time spent on learning about science, educational background, science-related post-secondary major, and teaching option have significant difference in science motivation, self-efficacy, attitude, and aspiration question scores. For time spent on learning about science, the cutting point was set up at one hour per week; the "one hour and above" group scored significantly higher than "shorter than one hour" group. For educational background, the STEM-related background group scored significantly higher than not STEM-related group. For the science-related post-secondary major variable, the participants have science-related major scored significantly higher than the others. For the teaching option variable, the STEM-related teaching option group scored significantly higher than non-STEM-related teaching option group. In sum, participants in "one hour and above" group, in STEM-related educational background group, in science-related post-secondary major group, or in STEM-related teaching option

group, comparing to the responding group, have significant higher motivation, self-efficacy, attitude, and aspiration towards science. Table 21 lists and summarizes the four significant predicting variables and responding question score statistics.

Table 21
Summary of Significant Predicting Variables and Responding Question Score Statistics

Variable	Option	Motivation		Self-Efficacy		Attitude		Aspiration	
		Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
Science	>=1h / week	25.00	3.72	37.34	5.09	30.71	3.76	25.43	6.45
study/activity time	<1h / week	20.00	4.53	29.18	8.43	25.74	4.82	16.45	6.68
Educational	STEM-related	26.43	2.77	39.41	4.67	31.34	3.85	27.52	6.09
background	Not STEM-related	20.57	4.42	30.21	7.50	26.68	4.78	17.79	6.66
A science-related	Yes	26.71	2.57	39.44	4.18	31.95	2.93	28.49	4.46
post-secondary major	No	20.64	4.39	30.51	7.72	26.56	4.83	17.68	6.77
Teaching option	STEM-related	25.51	3.88	38.42	5.86	30.83	4.06	26.17	7.37
	Not STEM-related	21.53	4.57	31.61	7.94	27.40	4.96	19.27	7.36
Average		23.30	3.86	34.52	6.42	28.90	4.25	22.35	6.48

3. The variable grade has significant difference in science motivation, self-efficacy, attitude scores – the second-year group did score significantly higher than the first-year group; however, grade variable does not have a significant difference in science aspiration. A possible explanation is the small sample size – there were only 15 second-year participants. Considering it is only a year of age difference, participants' opinions are unlikely to change a lot, I argue the significant difference between first-year and second-year is due to an accidental statistical error.

One-way ANOVA (Fisher Analysis of Variance) to Compare Means

In order to figure out if there are differences in survey scores by some variables having more than two conditions, Fisher's analyses of variance were applied. Analysis of variance (ANOVA) is used to investigate general differences between several means(Field, 2013). Since my purpose is to investigate if some variables (that have two or more levels) result in significant difference in science scores among each variable, one-way ANOVA is appropriate. Considering the sample size and the purpose of avoiding Type I error, if the variances are equal between the groups, *F*-ratios and *p*-values from ANOVA will be adopted; if variances are significantly different, Brown-Forsythe *F* values and responding *p*-values will be used (Field, 2013). Afterwards, to reveal the effect with further details, for the post hoc procedures, if there is equal variance, Bonferroni test will be applied; if variances are significantly different, Games-Howell test will be employed (Field, 2013).

In this part, totally seven variables will be examined: (a) program, (b) time spending on science learning or activities, (c) time spending on Web 2.0 for learning, (d) time using Web 2.0 for science learning, (e) how much a participant think Web 2.0 is helpful for science learning, (f) how much a participant enjoys using science-related Web 2.0 for learning, and (g) how much a participant think himself/herself good at using Web 2.0 for science learning. All the seven variables were extracted using multi-linear regression (see page 66), involve three or more groups.

Program.

Primary-Junior (P-J), Junior-Intermediate (J-I), and Intermediate-Senior (I-S) consist of the Bachelor of Education program. One-way ANOVA was used to test if there is significant difference in question scores among the three streams: P-J, J-I, and I-S. The results are presented in Table 22.

Table 22

One-way ANOVA Results for Question Scores on Program Conditions

Category	**Group** Program / Stream			*df1*	*df2*	*F*	*p*	**Post Hoc** *p*
Science Motivation	P-J	J-I	I-S	2	127	1.583	0.209	
Mean	22.86	20.09	22.70					
SD	4.23	5.39	5.05					
	P-J	*J-I*						*0.259*
	P-J		*I-S*					*1.000*
		J-I	*I-S*					*0.285*
Science Self-Efficacy	P-J	J-I	I-S	2	82.35	.187	.830	
Mean	33.10	34.45	33.27					
SD	6.30	5.20	9.30					
	P-J	*J-I*						*0.739*
	P-J		*I-S*					*0.993*
		J-I	*I-S*					*0.811*
Science Attitude	P-J	J-I	I-S	2	127	0.927	0.398	
Mean	28.77	26.55	28.14					
SD	4.18	5.64	5.39					
	P-J	*J-I*						*0.551*
	P-J		*I-S*					*1.000*
		J-I	*I-S*					*0.980*
Science Aspiration	P-J	J-I	I-S	2	25.298	0.664	0.523	
Mean	21.39	18.18	21.28					
SD	6.02	10.07	8.74					
	P-J	*J-I*						0.582
	P-J		*I-S*					0.997
		J-I	*I-S*					0.611

Four one-way between subjects' ANOVA were conducted to compare the effect of programs on science motivation, self-efficacy, attitude, and aspiration question scores in P-J, J-I, and I-S groups. There was not a significant effect of programs on science motivation self-efficacy, attitude, and aspiration question scores at the $p<0.05$ level for the three program conditions (motivation – $F(2,127) = 1.583$, $p = 0.209$; self-efficacy – $F(2,82.35) = 0.187$, $p = 0.830$; attitude – $F(2,127) = 0.927$, $p = 0.398$; aspiration – $F(2,25.298) = 0.664$, $p = 0.523$). Post hoc comparisons using Bonferroni and Games-Howell reveal that there is no significant difference between mean scores for different program conditions.

In sum, I conclude that different streams in the program do not influence participants' motivation, self-efficacy, attitude and aspiration towards science.

Time Spending on Science Learning and Activities.

This study aims to figure out if time spending on science learning and activities influences pre-service teacher's science question scores. The five levels of time ranges spent on learning about science are: 1 hour or less; more than 1 hour, up to 2 hours; more than 2 hours, up to 3 hours; more than 3 hours, up to 4 hours; and more than 4 hours per week. One-way ANOVA was used to test if there is significant difference in question scores among the five lengths of time. The results are presented in Table 23.

Table 23

One-way ANOVA Results for Question Scores on Time Spending on Science Learning and Activities Conditions

Category	**Group Time per week / h**					***df1***	***df2***	***F***	***p***	**Post Hoc *p***
Science Motivation	≤1	1-2	2-3	3-4	≥4	4	129	14.792	**0.000**	

Category			Group Time per week / h			*df1*	*df2*	***F***	***p***	**Post Hoc *p***
Mean	20.00	23.65	24.47	27	26.80					
SD	4.53	4.30	3.65	1.80	2.36					
	<1	*1-2*								***0.002***
	<1		*2-3*							***0.000***
	<1			*3-4*						***0.000***
	<1				*>4*					***0.000***
		1-2	*2-3*							*1.000*
		1-2		*3-4*						*0.348*
		1-2			*>4*					*0.182*
			2-3	*3-4*						*1.000*
			2-3		*>4*					*0.993*
				3-4	*>4*					*1.000*
Science Self-Efficacy	<1	1-2	2-3	3-4	>4	4	112.66	25.538	**0.000**	
Mean	29.18	35.03	36.68	39.77	40.73					
SD	8.43	5.55	4.37	3.86	3.36					
	<1	*1-2*								***0.002***
	<1		*2-3*							***0.000***
	<1			*3-4*						***0.000***
	<1				*>4*					***0.000***
		1-2	*2-3*							*0.800*
		1-2		*3-4*						*0.072*
		1-2			*>4*					***0.002***
			2-3	*3-4*						*0.356*
			2-3		*>4*					***0.034***
				3-4	*>4*					*0.971*
Science Attitude	<1	1-2	2-3	3-4	>4	4	96.126	18.901	**0.000**	
Mean	25.74	29.42	30.32	32.11	32.60					
SD	4.82	4.44	3.49	2.71	2.29					
	<1	*1-2*								***0.009***
	<1		*2-3*							***0.000***
	<1			*3-4*						***0.000***

Category	**Group Time per week / h**					***df1***	***df2***	***F***	***p***	**Post Hoc *p***
	<1				*>4*					***0.000***
		1-2	*2-3*							*0.942*
		1-2		*3-4*						*0.238*
		1-2			*>4*					***0.035***
			2-3	*3-4*						*0.583*
			2-3		*>4*					*0.175*
				3-4	*>4*					*0.990*
Science Aspiration	<1	1-2	2-3	3-4	>4	4	88.206	32.306	**0.000**	
Mean	16.44	21.54	24.95	29.00	30.67					
SD	6.68	6.46	5.25	4.55	3.75					
	<1	*1-2*								**0.013**
	<1		*2-3*							**0.000**
	<1			*3-4*						**0.000**
	<1				*>4*					**0.000**
		1-2	*2-3*							0.309
		1-2		*3-4*						**0.009**
		1-2			*>4*					**0.000**
			2-3	*3-4*						0.266
			2-3		*>4*					**0.007**
				3-4	*>4*					0.883

Four one-way between subjects' ANOVA were conducted to compare the effect of time spending on science learning and activities on science motivation, self-efficacy, attitude, and aspiration question scores among the five groups. There were significant effects of time lengths on science motivation, self-efficacy, attitude, and aspiration question scores on the $p<0.05$ level for the five conditions (motivation – $F(4, 129) = 14.792$, $p < 0.001$; self-efficacy – $(4, 112.66) = 25.538$, $p < 0.001$; attitude – $F(4, 96.126) = 18.901$, $p < 0.001$; aspiration – $F(4, 88.206) = 32.306$, $p < 0.001$).

Bonferroni test was conducted for motivation score post hoc tests and Games-Howell test was applied for self-efficacy, attitude and aspiration scores. The results indicated that "< 1 hour" group scored significantly lower than other four groups in all four science categories, $p < 0.02$. Beside the "< 1 hour" group, for science self-efficacy, the "> 4 hours" group scored significant higher than "1-2 hours" and "2-3 hours" groups; for science attitude, the "> 4 hours" group scored significant higher than "1-2 hours" group; for science self-efficacy, the "1-2 hours" group scored significantly lower than "> 4 hours" groups, and "2-3 hours" group scored significantly lower than the "> 4 hours" group.

Taken together, the results indicated that time spending on science learning and activities has an effect on science motivation, self-efficacy, attitude, and self-efficacy. Specifically, the results indicated that when participants spent less than one hour per week on learning about science, their motivation, self-efficacy, attitude, and self-efficacy towards science are significantly lower than other groups who work more than one hour. Also, when participants work on science more than four hours per week, their self-efficacy, attitude, and aspiration towards science are significantly higher than 1-2 hours groups.

Time Using Web 2.0 for Learning.

I aim to figure out if the time using Web 2.0 for learning effect pre-service teacher's science question scores. The five levels in science time per week are: 2 hours or less; more than 2 hours, up to 4 hours; more than 4 hours, up to 6 hours; more than 6 hours, up to 8 hours; and more than 8 hours. One-way ANOVA was used to test if there is significant difference in question scores among the five lengths of time. The results are presented in Table 24.

Table 24

One-way ANOVA Results for Question Scores on Time Using Web 2.0 in Learning Conditions

Category	Group Time per week / h					*df1*	*df2*	*F*	*p*	Post Hoc *p*
Science Motivation	<2	2-4	4-6	6-8	>8	4	127	0.173	0.952	
Mean	22.59	22.69	23.06	22.62	21.80					
SD	5.03	4.24	5.26	4.86	5.19					
	<2	*2-4*								*1.000*
	<2		*4-6*							*1.000*
	<2			*6-8*						*1.000*
	<2				*>8*					*1.000*
		2-4	*4-6*							*1.000*
		2-4		*6-8*						*1.000*
		2-4			*>8*					*1.000*
			4-6	*6-8*						*1.000*
			4-6		*>8*					*1.000*
				6-8	*>8*					*1.000*
Science Self-Efficacy	<2	2-4	4-6	6-8	>8	4	127	0.501	0.735	
Mean	34.72	32.86	34.64	32.37	33.80					
SD	8.33	7.06	7.01	8.67	9.22					
	<2	*2-4*								*1.000*
	<2		*4-6*							*1.000*
	<2			*6-8*						*1.000*
	<2				*>8*					*1.000*
		2-4	*4-6*							*1.000*
		2-4		*6-8*						*1.000*
		2-4			*>8*					*1.000*
			4-6	*6-8*						*1.000*
			4-6		*>8*					*1.000*
				6-8	*>8*					*1.000*
Science Attitude	<2	2-4	4-6	6-8	>8	4	127	0.346	0.847	

Category		Group Time per week / h				*df1*	*df2*	*F*	*p*	Post Hoc *p*
Mean	27.68	28.00	29.09	28.19	28.73					
SD	5.02	4.71	5.05	5.03	5.77					
	<2	*2-4*								*1.000*
	<2		*4-6*							*1.000*
	<2			*6-8*						*1.000*
	<2				*>8*					*1.000*
		2-4	*4-6*							*1.000*
		2-4		*6-8*						*1.000*
		2-4			*>8*					*1.000*
			4-6	*6-8*						*1.000*
			4-6		*>8*					*1.000*
				6-8	*>8*					*1.000*
Science Aspiration	≤2	2-4	4-6	6-8	≥8	4	127	1.338	0.259	
Mean	18.22	21.37	23.21	21.26	21.00					
SD	7.76	6.98	8.00	7.75	9.53					
	<2	*2-4*								*1.000*
	<2		*4-6*							*0.226*
	<2			*6-8*						*1.000*
	<2				*>8*					*1.000*
		2-4	*4-6*							*1.000*
		2-4		*6-8*						*1.000*
		2-4			*>8*					*1.000*
			4-6	*6-8*						*1.000*
			4-6		*>8*					*1.000*
				6-8	*>8*					*1.000*

Four one-way between subjects' ANOVA were conducted to compare the effect of time using Web 2.0 for learning on science motivation, self-efficacy, attitude, and aspiration question scores in in the five time groups. There was not a significant effect of time on science motivation self-efficacy, attitude, and aspiration question scores on the p<0.05 level for the five program conditions (motivation – $F(4,127) = 0.173$, $p = 0.952$;

self-efficacy – $F(4,127) = 0.501$, $p = 0.735$; attitude – $F(4,127) = 0.346$, $p = 0.847$; aspiration – $F(4,127) = 1.338$, $p = 0.259$). Post hoc comparisons using Bonferroni reveal that there is no significant difference between mean scores for different time using Web 2.0 for learning conditions.

Time Using Web 2.0 for Science Learning.

I aim to figure out if the time using Web 2.0 for science learning effect pre-service teacher's science question scores. The four levels in science time per week are: 2 hours or less; more than 2 hours, up to 4 hours; more than 4 hours, up to 6 hours; and more than 6 hours. One-way ANOVA was used to test if there is significant difference in question scores among the four lengths of time. The results are presented in Table 25.

Table 25

One-way ANOVA Results for Question Scores on Time Using Web 2.0 in Science Learning Conditions

Category		Group Time per week / h				*df1*	*df2*	*F*	*p*	Post Hoc *p*
Science Motivation		<2	2-4	4-6	>6	3	128	4.934	**0.003**	
	Mean	21.83	25.37	26.11	25.33					
	SD	4.85	3.66	2.57	5.50					
		<2	*2-4*							***0.031***
		<2		*4-6*						*0.053*
		<2			*>6*					*1.000*
			2-4	*4-6*						*1.000*
			2-4		*>6*					*1.000*
				4-6	*>6*					*1.000*
Science Self-Efficacy		<2	2-4	4-6	>6	3	5.951	5.665	**0.035**	
	Mean	32.27	36.93	39.33	39.00					
	SD	8.29	3.85	5.56	8.71					
		<2	*2-4*							***0.003***
		<2		*4-6*						***0.022***
		<2			*>6*					*0.630*
			2-4	*4-6*						*0.670*

Category	Group Time per week / h				df1	df2	F	p	Post Hoc p
		2-4		*>6*					*0.973*
			4-6	*>6*					*1.000*
Science Attitude	<2	2-4	4-6	>6	3	128	4.899	**0.003**	
Mean	27.51	31.50	30.88	32.33					
SD	5.06	2.96	4.19	2.88					
	<2	*2-4*							***0.014***
	<2		*4-6*						*0.268*
	<2			*>6*					*0.528*
		2-4	*4-6*						*1.000*
		2-4		*>6*					*1.000*
			4-6	*>6*					*1.000*
Science Aspiration	<2	2-4	4-6	>6	3	128	9.758	**0.000**	
Mean	19.47	27.18	28.55	28.33					
SD	7.42	5.96	6.91	5.50					
	<2	*2-4*							***0.001***
	<2		*4-6*						***0.003***
	<2			*>6*					*0.228*
		2-4	*4-6*						*1.000*
		2-4		*>6*					*1.000*
			4-6	*>6*					*1.000*

Four one-way between subjects' ANOVA were conducted to compare the effect of Web 2.0 in science learning time on science motivation, self-efficacy, attitude, and aspiration question scores among the four time groups. There were significant effects of time lengths on science motivation, self-efficacy, attitude, and aspiration question scores on the $p<0.05$ level for the five conditions (motivation – $F(3, 128) = 4.934$, $p = 0.003$; self-efficacy – (3,5.951) = 5.665, $p = 0.035$; attitude – $F(3, 128) = 4.899$, $p = 0.003$; aspiration – $F(3, 128) = 9.578$, $p < 0.001$).

Bonferroni tests were conducted for motivation, attitude, and aspiration scores post hoc tests and Games-Howell test was applied for self-efficacy scores. The results indicated that "< 2 hours" group scored significantly higher than other four groups in all four science categories, $p < 0.04$. Beside the "< 2 hours" group, for science self-efficacy and aspiration, the "2-4 hours" group scored significant higher than "4-6 hours" group.

Taken together, the results indicated that Web 2.0 usage time for science learning time has an effect on science motivation, self-efficacy, attitude, and self-efficacy. Specifically, the results indicated that when participants spending less than two hours on science using Web 2.0 per week, their motivation, self-efficacy, attitude, and self-efficacy towards science are significantly lower than other groups who work more than two hours. Also, when participants spend 2-4 hours on science using Web 2.0 per week, their self-efficacy and aspiration towards science are significant lower than the 4-6 hours group.

Web 2.0 Helpfulness for Science Learning.

I aim to figure out if how much a participant considers Web 2.0 is helpful for science learning affects pre-service teacher's science question scores. The five levels in the helpfulness are: Strongly agree (St. A), Somewhat agree (Sw. A), Neither agree nor disagree (N), Somewhat disagree (Sw. D), and Strongly disagree (St. D). However, no one responded as strongly disagree, which leads only four levels of helpfulness for ANOVA analysis. One-way ANOVA was used to test if there is significant difference in question scores among the four attitudes. The results are presented in Table 26.

Table 26

One-way ANOVA Results for Question Scores on Web 2.0 Helpfulness for Science Learning

Category		Group *Helpfulness*				*df1*	*df2*	*F*	*p*	Post Hoc *p*
Science Motivation		St.A	Sw.A	N	Sw.D	3	128	0.682	0.565	
	Mean	23.07	22.40	22.33	19.75					
	SD	5.01	4.45	5.00	6.84					
		St.A	*Sw.A*							*1.000*

Category		Group *Helpfulness*			*df1*	*df2*	*F*	*p*	Post Hoc *p*
	St.A		*N*						*1.000*
	St.A			*Sw.D*					*1.000*
		Sw.A	*N*						*1.000*
		Sw.A		*Sw.D*					*1.000*
			N	*Sw.D*					*1.000*
Science Self-Efficacy	St.A	Sw.A	N	Sw.D	3	128	0.986	0.401	
Mean	19.56	20.29	23.28	20.00					
SD	7.61	6.63	10.18	12.67					
	St.A	*Sw.A*							*1.000*
	St.A		*N*						*0.557*
	St.A			*Sw.D*					*1.000*
		Sw.A	*N*						*0.986*
		Sw.A		*Sw.D*					*1.000*
			N	*Sw.D*					*0.557*
Science Attitude	St.A	Sw.A	N	Sw.D	3	128	3.09	0.051	
Mean	29.71	27.72	26.71	25.00					
SD	4.21	4.91	6.10	5.71					
	St.A	*Sw.A*							*0.219*
	St.A		*N*						*0.111*
	St.A			*Sw.D*					*0.387*
		Sw.A	*N*						*1.000*
		Sw.A		*Sw.D*					*1.000*
			N	*Sw.D*					*1.000*
Science Aspiration	St.A	Sw.A	N	Sw.D	3	128	2.027	0.113	
Mean	23.11	20.11	19.38	17.75					
SD	7.36	8.09	7.92	10.50					
	St.A	*Sw.A*							*0.300*
	St.A		*N*						*0.405*
	St.A			*Sw.D*					*1.000*
		Sw.A	*N*						*1.000*
		Sw.A		*Sw.D*					*1.000*
			N	*Sw.D*					*1.000*

Four one-way between subjects' ANOVA were conducted to compare the effect of how people think Web 2.0 is helpful for science learning on science motivation, self-efficacy, attitude, and aspiration question scores in the four attitudes groups. There was no significant effects of different helpfulness attitudes on science motivation, self-efficacy, attitude, and aspiration question scores on the $p<0.05$ level for the four conditions (motivation – $F(3, 128) = 0.682$, $p = 0.565$; self-efficacy – $F(3, 128) = 0.986$, $p = 0.401$; attitude – $F(3, 128) = 3.09$, $p = 0.051$; aspiration – $F(3, 128) = 2.027$, $p = 0.113$).

Bonferroni tests were conducted for motivation, attitude, and aspiration scores post hoc tests and Games-Howell test was applied for self-efficacy scores. The results indicated that there is no difference between the four groups in either of the four science scores.

Taken together, the results indicated that how people think Web 2.0 helpful for science learning does not have an effect on science motivation, self-efficacy, attitude, and self-efficacy.

Enjoyment in Using Science-related Web 2.0 for Learning.

The study aims to figure out if how much a participant enjoys using science-related Web 2.0 for learning affects pre-service teacher's science question scores. The five levels in the enjoyment attitude are: Strongly agree (St. A), Somewhat agree (Sw. A), Neither agree nor disagree (N), Somewhat disagree (Sw. D), and Strongly disagree (St. D). However, there are too few participants in somewhat disagree group (three people) and strongly disagree group (2 people), I combined the strongly disagree group with somewhat disagree group, and One-way ANOVA was used to test if there is significant difference in question scores among the three groups of enjoyment. The results are presented in Table 27.

Table 27

One-way ANOVA Results for Question Scores on How much a participant enjoys using science-related Web 2.0 for learning

Category		Group Enjoyment		*df1*	*df2*	*F*	*p*	Post Hoc *p*
Science Motivation	Agree	Neutral	Disagree	2	128	0.874	0.420	
Mean	22.72	21.00	23.00					
SD	4.75	5.41	4.52					
	Agree	*Neutral*						*0.584*
	Agree		*Disagree*					*1.000*
		Neutral	*Disagree*					*1.000*
Science Self-Efficacy	Agree	Neutral	Disagree	2	128	3.552	**0.032**	
Mean	33.91	28.26	34.80					
SD	7.65	9.16	6.97					
	Agree	*Neutral*						***0.029***
	Agree		*Disagree*					*1.000*
		Neutral	*Disagree*					*0.324*
Science Attitude	Agree	Neutral	Disagree	2	128	3.662	**0.028**	
Mean	29.61	25.06	29.60					
SD	4.72	6.13	4.66					
	Agree	*Neutral*						***0.029***
	Agree		*Disagree*					*1.000*
		Neutral	*Disagree*					*0.266*
Science Aspiration	Agree	Neutral	Disagree	2	128	2.095	0.127	
Mean	21.65	17.66	18.00					
SD	7.98	6.98	7.51					
	Agree	*Neutral*						*0.202*
	Agree		*Disagree*					*0.933*
		Neutral	*Disagree*					*1.000*

Four one-way between subjects' ANOVA were conducted to compare the effect of how people think they enjoy using Web 2.0 for science learning on science motivation, self-efficacy, attitude, and aspiration question scores among the four groups. There were no significant difference in enjoyments levels on science motivation and aspiration question scores on the $p<0.05$ level for the three conditions (motivation – $F(2, 128) = 0.874$, $p = 0.420$; aspiration – $F(2, 128) = 2.095$, $p = 0.127$), but there were significant effects of different enjoyments levels on science motivation and aspiration question scores on the $p<0.05$ level for the three conditions (self-efficacy – $F(2, 128) = 3.552$, $p = 0.032$; attitude – $F(2, 128) = 3.662$, $p = 0.028$).

Bonferroni tests were conducted for motivation, self-efficacy, attitude, and aspiration scores post hoc tests. The results indicated that there is no difference between either of the four groups in science motivation and aspiration scores; and "Neither agree nor disagree" group scored significantly higher than agree groups in science self-efficacy and attitude, $p < 0.03$.

Taken together, the results indicated that how people think they enjoy using Web 2.0 for science learning do not have effects on science motivation and aspiration but has a significant effect on science self-efficacy and attitude. More specifically, the results indicated that "neither agree nor disagree" group had significantly lower self-efficacy and attitude than the "agree" group.

How Much a Participant Thinks Himself or Herself Good as Being at Using Web 2.0 for Science Learning.

The study aims to figure out if the how much a participant thinks himself/herself being good at using Web 2.0 for science learning affects pre-service teacher's science question scores. The five levels in the confidence are: strongly agree (St. A), somewhat agree (Sw. A), neither agree nor disagree (N), somewhat disagree (Sw. D), and strongly disagree (St. D). One-way ANOVA was used to test if there is significant difference in question scores among the five groups of confidence. The results are in Table 28.

Table 28

One-way ANOVA Results for Question Scores on How much a participant think himself/herself good at using Web 2.0 for science learning

Category			Group Good at			*df1*	*df2*	*F*	*p*	Post Hoc *p*
Science Motivation	St.A	Sw.A	N	Sw.D	St.D	4	126	3.684	**0.007**	
Mean	21.85	25.00	21.08	23.51	20.58					
SD	5.69	3.86	4.27	4.59	6.44					
	St.A	*Sw.A*								*1.000*
	St.A		*N*							*1.000*
	St.A			*Sw.D*						*1.000*
	St.A				*St.D*					*1.000*
		Sw.A	*N*							***0.017***
		Sw.A		*Sw.D*						*1.000*
		Sw.A			*St.D*					*0.094*
			N	*Sw.D*						*0.138*
			N		*St.D*					*1.000*
				Sw.D	*St.D*					*0.538*
Science Self-Efficacy	St.A	Sw.A	N	Sw.D	St.D	4	46.21	4.84	**0.002**	
Mean	35.57	38.14	30.23	34.13	32.16					
SD	4.11	4.29	8.55	7.29	10.16					
	St.A	*Sw.A*								*0.631*
	St.A		*N*							*0.106*
	St.A			*Sw.D*						*0.938*
	St.A				*St.D*					*0.840*
		Sw.A	*N*							***0.000***
		Sw.A		*Sw.D*						*0.052*
		Sw.A			*St.D*					*0.345*
			N	*Sw.D*						*0.143*
			N		*St.D*					*0.972*
				Sw.D	*St.D*					*0.968*
Science Attitude	St.A	Sw.A	N	Sw.D	St.D	4	126	4.214	**0.003**	

Category			Group Good at			*df1*	*df2*	*F*	*p*	Post Hoc *p*
Mean	30.00	31.19	26.52	28.77	26.66					
SD	2.88	3.57	4.87	5.03	5.85					
	St.A	*Sw.A*								*1.000*
	St.A		*N*							*0.745*
	St.A			*Sw.D*						*1.000*
	St.A				*St.D*					*1.000*
		Sw.A	*N*							***0.003***
		Sw.A		*Sw.D*						*0.577*
		Sw.A			*St.D*					*0.098*
			N	*Sw.D*						*0.257*
			N		*St.D*					*1.000*
				Sw.D	*St.D*					*1.000*
Science Aspiration	St.A	Sw.A	N	Sw.D	St.D	4	126	4.354	**0.002**	
Mean	19.57	26.04	18.39	22.28	18.33					
SD	6.62	7.15	6.69	8.29	8.78					
	St.A	*Sw.A*								*0.516*
	St.A		*N*							*1.000*
	St.A			*Sw.D*						*1.000*
	St.A				*St.D*					*1.000*
		Sw.A	*N*							***0.002***
		Sw.A		*Sw.D*						*0.619*
		Sw.A			*St.D*					*0.093*
			N	*Sw.D*						*0.152*
			N		*St.D*					*1.000*
				Sw.D	*St.D*					*1.000*

Four one-way between subjects' ANOVA were conducted to compare the effect of how people think themselves as being good at using Web 2.0 for science learning on science motivation, self-efficacy, attitude, and aspiration question scores in the four attitudes groups. There were significant effects of different confidence levels on science motivation, self-efficacy, attitude, and aspiration question scores on the $p<0.05$ level for the five conditions (motivation – $F(4,126) = 3.684$, $p = 0.007$; self-efficacy – $F(4, 46.21) = 4.84$, $p = 0.002$; attitude – $F(4,126) = 4.214$, $p = 0.003$; aspiration – $F(4, 126) = 4.354$, $p = 0.002$).

Bonferroni tests were conducted for motivation, attitude, and aspiration scores post hoc tests and Games-Howell test was applied for self-efficacy scores. The results indicated that “Neither agree nor disagree” group scored significantly lower than other four groups in all four science categories, $p < 0.02$.

Taken together, the results indicated that how people think themselves about how good they are at using Web 2.0 for science learning have an effect on science motivation, self-efficacy, attitude, and self-efficacy. Specifically, the results indicated that when participants have neutral confidence in using Web 2.0 for science learning, their motivation, self-efficacy, attitude, and self-efficacy towards science are significantly lower than the somewhat agree groups but are significantly different than other three groups.

Summary and Discussion of One-Way ANOVA.

The purpose of one-way ANOVA analysis is to investigate the possible difference in survey scores by some variables having three or more conditions. In this part, seven variables containing three or more groups were examined to explore the differences. The seven variables are: program, time spending on science learning and activities, time using Web 2.0 for learning, time using Web 2.0 for science learning, how much a participant think Web 2.0 is helpful for science learning, how much a participant enjoys using science-related Web 2.0 for learning, and how much a participant thinks himself/herself as being good at using Web 2.0 for science learning. These demographic, science and Web 2.0 usage-related variables were extracted using multi-linear regression (see page 66), involve three or more groups. The results indicate that:

1. Three variables – program, time using Web 2.0 for learning, and how much a participant thinks Web 2.0 is helpful for science learning – do not influence participants' motivation, self-efficacy, attitude and aspiration towards science significantly. Their *p*-values are all above 0.2, and none of the post hoc results displays significant effect between the groups.
2. Two variables, time spent on learning about science and time using Web 2.0 for science learning have significant effect on science motivation, self-efficacy, attitude and aspiration scores, based on the one-way ANOVA results. The boxplots below (Figure 5 and Figure 6) reflect detailed post hoc comparisons. Figure 5 shows how time spent on science learning influence science question scores between groups. Post hoc comparisons suggest that "shorter than one hour per week" groups score significantly lower than the other four groups in all categories, indicating that students spending less than one hour in science have significantly lower motivation, self-efficacy, attitude, and aspiration towards science. Also, for science self-efficacy scores, the longest group (more than four hours per week) scored significantly higher than "> 1 hour" "1~2 hours" "2~3 hours" groups, indicating the participants spending more than four hours per week on science have significantly higher motivation, self-efficacy, attitude, and aspiration towards science, compared to the "> 1 hour" "1~2 hours" "2~3 hours" participants. The differences in science aspiration scores between groups are

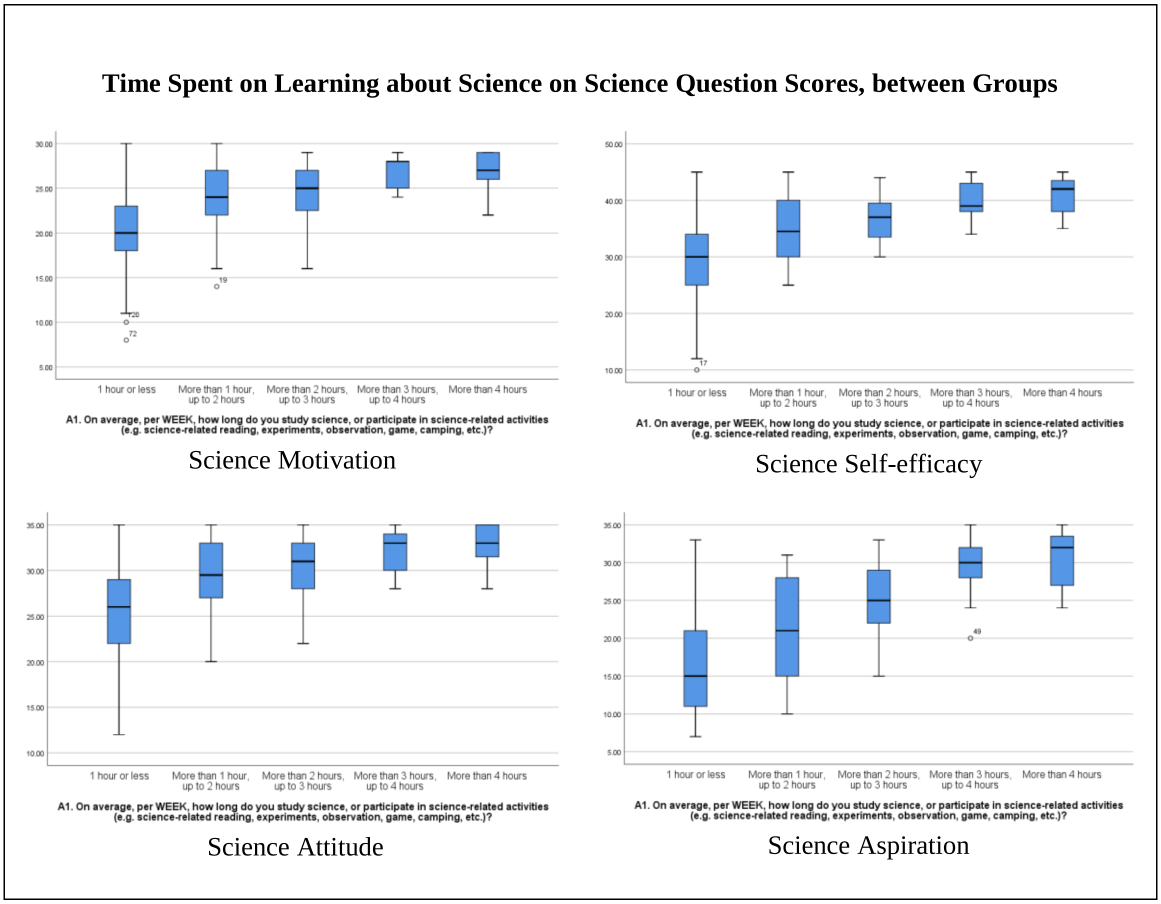

Figure 5. Time spent on Science Learning and Activity Question Scores, between Groups

relatively even. Most groups scored significantly different from each other, except "1~2 hours" compared with "2~3 hours", "2~3 hours" compared with "3~4 hours", and "3~4 hours" compared with ">4 hours", which are not significantly different from each other.

Figure 6 shows how time using Web 2.0 for science learning influence science question scores between groups. Post hoc comparisons suggest that the "shorter than two hours per week" groups score significantly lower than "2-4 hours" group in all categories, and higher than "4-6 hours" groups in aspiration and self-efficacy. However, boxplots show that except aspiration, in the other categories,

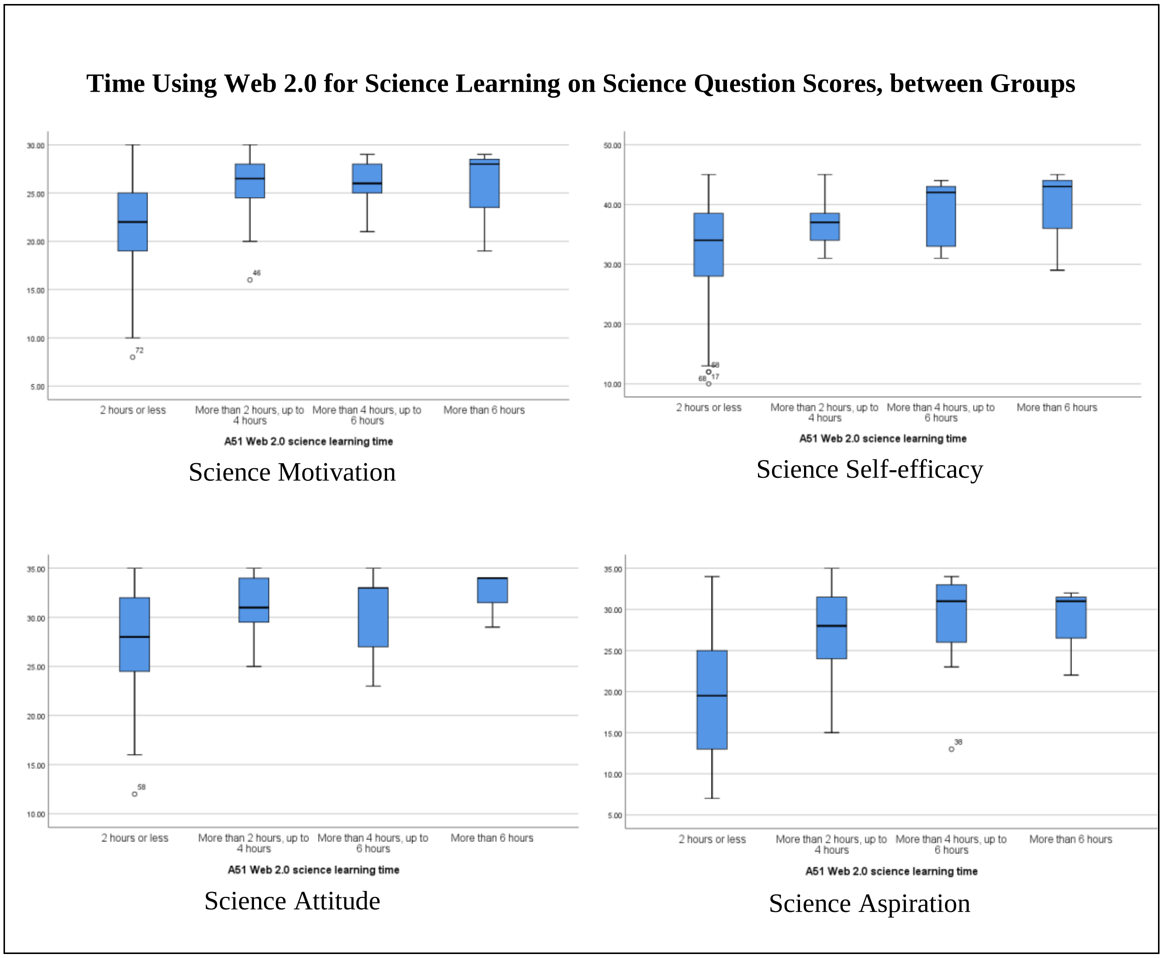

Figure 6. Time Using Web 2.0 for Science Learning on Science Question Scores, between Groups

the means and standard deviations for the last three groups are close to each other. A possible reason is that there are very few responses (28 people) in the last three groups – which suggests it is accidental response bias leading to the result.

In conclusion, ANOVA results support statistically significant variable “time using Web 2.0 for science learning” will be considered as a key influence variable of science motivation, self-efficacy, attitude, and aspiration, and people in group “<2 hours” scored significantly lower than other three groups, indicating the participants spending less than two hours per week in using Web 2.0 to learn science have significantly lower motivation, self-efficacy, attitude, and aspiration towards science, compared to the participants spending more than two hours per week using Web 2.0 to learn science.

3. For the last two variables, "enjoyment in using science-related Web 2.0 for learning" and "how much a participant think himself/herself as being good at using Web 2.0 for science learning", the ANOVA results showed that the enjoyment variable did not have a significant effect on participants' motivation and aspiration towards science, but they had a significant effect on self-efficacy and attitude scores ($p < 0.05$); the confidence variable had a significant effect on all four categories. The post hoc comparisons reveal that the "one and only" neutral response group showed significant difference compared to other groups – which was bit of an anomaly. One explanation could be that participants chose a neutral response to avoid choosing extreme responses (Hurley, 1998; Moors, 2008; Presser & Schuman, 1980). The possibility of this made the two questions no longer suitable to work as variables. In sum, "enjoyment in using science-related Web 2.0 for learning" and "how much a participant think himself/herself good at using Web 2.0 for science learning" were not considered as key variables of science motivation, self-efficacy, attitude, and aspiration.

In sum, the one-way ANOVA results indicated that variables "science study or activity time" and "time using Web 2.0 for science learning" are significant variables to influence science motivation, self-efficacy, attitude and aspiration scores. The post hoc tests show that, for the "science study or activity time" variable, the "less than one hour per week" group scored significantly lower than other groups – this also matches the independent *t*-test result. And for "time using Web 2.0 for science learning", the group "less than two hours per week" group scored significantly lower than other groups. The two predicting variables both indicate that there is a relationship between longer time spent on science learning and higher science motivation, self-efficacy, attitude, and aspiration.

CHAPTER 5: CONCLUSION

This chapter is the conclusion of this thesis. It includes a summary of major theories, contexts and findings of the study, critiques the limitations, talks about the implications of the findings, and previews possible directions for future studies. The present research constructed and validated a science affects survey from the four categories of motivation, self-efficacy, attitude and aspiration. The research indicates that pre-service teachers have high motivation, high self-efficacy, positive attitude towards science and neutral aspirations for science-related careers. Summed scores in each of the four categories were predicted by other categories, except for self-efficacy and aspiration, which did not predict each other. In addition, five predictors – time spent on learning about science, time using Web 2.0 to learn science, educational background, science-related major, and teaching option – influenced pre-service teachers' science motivation, self-efficacy, attitude, and aspiration.

Summary

Introduction.

The purpose of the research was to investigate Ontario pre-service teachers' affect and aspiration towards science and Web 2.0. As such, a survey measuring pre-service teachers' science and Web 2.0 motivation, self-efficacy, attitude, and aspiration was determined to be a good approach. However, existing survey instruments (e.g., Avramidis, Bayliss, & Burden, 2000; Croll, 2008; Elliot & Murayama, 2008; Liaw, Huang, & Chen, 2007; Puvirajah et al., 2015; Uguroglu, Schiller, & Walberg, 1981) did not satisfy my requirements because none of them met the criteria for assessing science and Web 2.0 together, were not specifically applicable to pre-service teachers, and did not measure self-efficacy according to Ontario science curriculum standards. Therefore, I had to construct and validate an instrument for this unique context. The research objectives of this study were: (1) to build a survey about science and Web 2.0 affect and aspiration, (2) to validate the survey, and (3) to gain an overall understanding of science and Web 2.0 affects, and to seek relationships between variables. The following three research questions supported the research objectives: (1) What are pre-service teachers' motivation, self-efficacy, attitude, and aspiration towards science? (2) Is there any relationship between pre-service teachers' motivation, self-efficacy, attitude, and aspiration about science and Web 2.0 technology? (3) What social and demographic factors, if any, are associated with pre-service teachers' motivation, self-efficacy, attitude, and aspiration about science and Web 2.0 technology?

The developed survey, namely the Western Survey of Science and Web 2.0 Affect and Aspiration (WSSWAA), consists of two types of questions: multiple-choice (including multiple-response) questions (30 items) and Likert-scale questions (63 items). The multiple-choice questions, aiming to collect demographic information and science/Web 2.0 learning/usage habits, were analyzed as potential predicting variables. The Likert-scale questions were used to provide quantitative data for describing pre-service teachers' affects, to explore the relationship among the four categories, and to investigate influential predictors.

Literature.

The demographic questions in this study are referenced from the Canadian census profile (Census Program, 2017) and the Western University Bachelor of Education Program (Western University, 2017), and collected information about education, teaching options, specialty areas, age, gender, race, and about parental educational backgrounds.

The science and Web 2.0 usage questions focused on learning and usage habits. The scale questions were based on a series of theories about motivation, self-efficacy, attitude, and aspiration because studies show that motivation, self-efficacy, and attitude play significant roles in academics, especially science-related academic performances and achievements. Furthermore, motivation, self-efficacy and attitude influence science-related career aspirations (Bandura, Barbaranelli, Caprara, & Pastorelli, 2001; Saks, 1995), as all four categories are interrelated (Bandura, 1997; Pajares & Graham, 1999; Saks, 1995; Zimmerman & Bandura, 1994; Zimmerman & Kitsantas, 1999).

Motivation has normally been seen as an important predictor of academic achievement, especially in science (Ames & Archer, 1988; Hein, 2009; Napier & Riley, 1985; Wlodkowski, 2008). In this study, it is defined as the behavior, enthusiasm or desire that drives individuals' actions to learn and/or to apply science and Web 2.0. Major motivation theory frameworks applied in the study incorporate both self-determination theory (Deci & Ryan, 2008; Ryan & Deci, 2000) and goal-oriented theory (Ames, 1992; Ford, 1992). Self-determination theory classifies motivation into two types by these orientations: intrinsic motivation (from inherent interests and enjoyments) and extrinsic motivation (for some outcomes) (Deci & Ryan, 2008; Ryan & Deci, 2000). Goal-oriented theories (Ames, 1992; Elliott & Dweck, 1988; Ford, 1992; Grant & Dweck, 2003) analyzes motivation from a mastery goal orientation and a performance goal orientation (Ames, 1992; Linnenbrink & Pintrich, 2002; Meece, Anderman, & Anderman, 2006). The two motivation theories were clearly revealed in the results of the principal component analysis (PCA) as motivation *factor 1.1*, *goal-oriented motivation*, and *factor 1.2, self-determination motivation*.

Self-efficacy is another factor widely believed to be significant in influencing academic progress and more specifically science learning, as willpower rather than the real ability, is a key factor in predicting a person's potential achievement (Bandura, 1997; Britner & Pajares, 2006; Pajares & Britner, 2001; Pajares, Johnson, & Usher, 2017; Schunk, 1991; Zeldin & Pajares, 2000). Key self-efficacy theories applied in this study, as to what extent people master their behaviors, were extracted from Bandura's social cognitive theory (Bandura, 1977, 1982, 1997; Schunk, 1991). In this study, self-efficacy refers to people's beliefs about their ability to master science and Web 2.0 and is measured by its task-specific strength. In response to the research objectives, three science curriculum expectations from the *Ontario Curriculum: Science* (OCS) (Ontario & Ministry of Education, 2008), (1) knowledge and understanding, (2) thinking and investigation, (3) communication, and (4) application were applied as an outline to set up the survey items. The PCA results only extracted one factor from science items, which indicates that these self-efficacy items have good consistency.

Positive *attitude* has long been seen as a principal factor in better learning in independent subject areas such as science (Tsai et al., 2012), technology (Kay, 1990; Singh, Granville, & Dika, 2002), Web 2.0 (Baltaci-Goktalay & Ozdilek, 2010; Hartshorne & Ajjan, 2009; Tusubira & Mulira, 2004) or other subjects (R. C. Gardner, 2010). Research suggests that attitudes towards science and technology also share a close relationship with motivations, self-efficacies and career aspirations (Lu, Chen, Hong, & Yore, 2016; Osborne, Simon, & Collins, 2003; Singh et al., 2002; Tuan, Chin, & Shieh, 2005). In this study, attitude is defined as people's personal judgments, emotions, opinions, and senses of worth about science and Web 2.0. The design of attitude measurements is referenced from various studies, and the five sub-categories were designed as an outline for the attitude items: (a) importance of science/Web 2.0, (b) interest in science/Web 2.0, (c) theoretical knowledge about science/Web 2.0 in school, (d) practical operation in science/Web 2.0 in school, and (e) Science/Web 2.0 beyond school. The analysis extracted two factors from the items, namely *personal engagements* and *value to society*.

Aspiration, as the index of pursuing science and/or technology-related careers, has garnered wide concern from the public and many governments (Archer & DeWitt, 2017, p. 3; Council for Industry and Higher Education, 2009; House of Lords, 2012; U. S. Department of Education, 2000; UK Commission for Employment and Skills, 2012). As most research sets up aspiration items as descriptive statements (Stage & Hossler, 1989; Uwah, McMahon, & Furlow, 2008), in this research, the aspiration items focus on participants' intentions for general interest and professional development about science and Web 2.0. Eventually, the PCA results extracted only one factor, which indicates that the aspiration items have good internal consistency.

Methods.

Bachelor of Education (BEd) students in the Faculty of Education, at Western University in London, Ontario, were surveyed using the WSSWAA online questionnaire. Descriptive data was used to present demographic, science learning and Web 2.0 usage information; principal component analysis (PCA) and Cronbach's alpha reliability analyses were applied to validate survey items and to extract factors; multiple linear regressions were operated to explore possible predicting variables and to build prediction models among the four categories; independent sample *t*-tests were utilized to examine the predicting variables consisting of two units; and one-way ANOVA was employed to test the predicting variables consisting of three or more units.

Results.

Sample.

The general response rate of the survey was 21.83% (n = 169); most second-year pre-service teachers were difficult to contact as they were in the field and the response rate of first-years was 35.6% (n = 136). There were 134 valid responses, 99 females (73.9%) and 29 males (21.6%). Of all respondents, 11.2% were in STEM-related specialty areas, and 27.8% chose STEM-related teaching options. Overall demographic information of samples, especially visible minorities, matched Ontario census data quite well (Census Program, 2017); however, the sample for this study contains fewer Caucasian, South Asian, and African American students, but includes more multiple-ethnicity visible minorities when compared with Ontario census data. In addition, descriptive statistics indicated that pre-service teachers were keen on using Web 2.0 technologies in their daily lives and showed strong interest and a positive attitude about using Web 2.0 as a tool for studying in general or learning about science. More specifically, over 85% of participants use Web 2.0 more than seven hours per week, and over 85% of participants use Web 2.0 for learning more than two hours per week; however, only 20% use Web 2.0 for science more than two hours per week. Even so, students highly recognized the role Web 2.0 plays in science learning – over 80% considered Web 2.0 to be helpful and enjoyable for science learning, and half used Web 2.0 for high school level science learning; however, only 20% considered themselves good at using Web 2.0 for science learning.

Instrument Validation.

Principal component analysis was applied to all Likert-scale questions. The results indicated that all Web 2.0 scale questions needed to be removed; in other words, this study could not provide descriptive statistics for Web 2.0 scale questions. A total of 29 science scale items were kept and classified into four categories: motivation, self-efficacy, attitude, and aspiration. PCA results also classified the items into six more detailed factors: goal-oriented (motivation, 3 items), self-determination (motivation, 3 items), self-efficacy (9 items), personal engagement (attitude, 5 items), value to society (attitude, 2 items), and aspiration (7 items). The results of the PCA, the KMO measure of sampling adequacy, and the Cronbach's alpha value criteria confirmed that the sample and the instrument are valid, reliable, and have internal consistency.

Descriptive Statistics.

This section answers the first research question: "What are pre-service teachers' motivation, self-efficacy, attitude, and aspiration towards science?" In this study, a higher score represents a more positive response. Hence, participants have high science motivation (*median* = 4.17, *mean* = 3.77, *SD* = 1.19), high self-efficacy (*median* = 3.89, *mean* = 3.72, *SD* = 1.10), a positive attitude (*median* = 4.15, *mean* = 4.04, *SD* = 0.96), and medium aspiration tendency (*median* = 3.08, *mean* = 3.02, *SD* = 1.40) towards science. The largest mean value and the smallest standard deviation value come from *attitude factor 2, value to society* (*median* = 5.00, *mean* = 4.73, *SD* = 0.53), indicating that participants highly recognize the value of science in society. The smallest standard deviation value is from *motivation factor 2*, *self-determination* (*SD* = 1.44), suggesting that respondents presented various levels of self-determination motivation. The lowest mean score comes from aspiration (*median* = 3.08, *mean* = 3.02, *SD* = 1.40), which is very close to 3 (neutral value). The students who chose STEM-related careers (27.8% of samples, *mean* = 3.74) scored significantly higher than non-STEM-related students (72.2% of samples, *mean* = 2.74) on the aspiration scale (p < .001).

Prediction Models.

This section answers the second research question: "Is there a relationship between pre-service teachers' motivation, self-efficacy, attitude, and aspiration about science and Web 2.0 technology?" Studies suggested that the four categories are interrelated, and the four prediction models from the multi-linear regression results confirmed the theoretical frameworks. The results indicate that: (1) self-efficacy and aspiration are effective predictors of motivation, (2) attitude and motivation are effective predictors of self-efficacy, (3) self-efficacy and aspiration are effective predictors of attitude, (4) attitude and motivation are effective predictors of aspiration, (5) self-efficacy and aspiration are not effective predictors of each other, and (6) motivation and attitude are not effective predictors of each other.

Summary of Predicting Variables.

This section answers the last research question. The significant difference between or among groups based on question scores are listed as follows: (1) Independent sample *t*-tests reveal that different science study times, educational backgrounds, science-related post-secondary majors, and teaching options have a significant impact on science motivation, self-efficacy, attitude, and aspiration question scores (p < 0.05). The higher responses group (higher score) are the people who study science more than one hour per week, who have STEM-related educational backgrounds, who have science-related post-secondary majors, or who chose STEM-related teaching options in the BEd program. (2) One-way ANOVA results indicate that science study time and time using Web 2.0 to learn about science are significant predictor variables (p < 0.05). Generally, science scores in all four categories showed a positive correlation with science study time and the time using Web 2.0 for science purposes. Compared to other groups, the “less than one hour per week science study time” group and the “less than two hours per week using Web 2.0 to learn about science” group reflected significantly lower motivation, self-efficacy, attitude, and aspiration towards science ($p < 0.05$); especially for aspiration, there was a significant difference among almost every group in both variables ($p < 0.05$), suggesting different science learning times, with or without using Web 2.0 for assistance, have a considerable effect on aspiration.

Limitations

As with any exploratory research, though I was able to construct and validate the necessary instrument, which yielded some findings, I must still address the limitations in the current survey’s design, sampling and data analysis.

Response Bias.

The WSSWAA survey is a kind of self-report survey asking participants about their personal opinions about science and technology, and the main part is the Likert-scale questions about science and Web 2.0 affects. However, common response biases in sociology studies like, acquiescent bias and social desirability bias (Cronbach, 1942; Paulhus, 1991; Sprott & Edwards, 1959), might also exist in the study. The Likert-scale response itself has a limitation of response bias (Moors, Kieruj, & Vermunt, 2014). To minimize the response bias, we put the survey online and kept it anonymous, placed demographic questions at the end of the questionnaire to minimize social expectation influence, set up very few negatively worded/reverse-coded items to reduce response pattern biases, and constructed attention check questions to screen out unserious responses (Bolstad, 2017; Hinkin, 1995; Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). Still, some side effects of response bias were found in the results. For example, as mentioned earlier, the average score for *motivation factor 2, self-determination* is lower than most scores for other factors, possibly because these questions are somehow related to previous experience rather than general opinions, so the score is less affected by social desirability bias. Another example is the order of scale items, in that near the end of the survey is where more neutral responses came up, which was likely because of acquiescent bias – some participants were eager to finish the survey so they just chose neutral responses impatiently as I discussed in the analyses of the one-way ANOVA (see page 99). This response bias is a possible factor that rendered Web 2.0 scale questions unsuitable for PCA and mean comparing.

Sampling.

The research aims to understand Ontario pre-service teachers' affect about science and Web 2.0. However, some objective conditions – there was no funding supporting the research, the time for this study was limited to seven months, the survey was only conducted at the Faculty of Education of Western University in London, Ontario, Canada – limited the population to 744, and the final valid sample size was 134. Moreover, when the ethics application was approved, all second-year pre-service teachers had already gone out for practicum; although I tried various methods of attracting both first-year and second-year students, including but not limited to displaying posters, sending mass emails, posting notices in Facebook groups, and asking professors to broadcast the study, only about 10% of the samples were second-year BEd students. This means that the grades were not evenly distributed. In addition, more than 70% of the valid samples were collected from female students, and the proportion of white students was much less than the corresponding Ontario census data (Census Program, 2017), indicating there is a difference between the sample and Ontario's population. Unfortunately, I was not able to obtain Ontario pre-service teachers' demographic information, so it was impossible to judge whether or not the sampling was consistent with the overall teacher education program student distribution in Ontario.

Integrity and Validity.

Since Web 2.0 scale questions did not pass the PCA examination, all Web 2.0 scale questions (22 items) were removed, which made it impossible to provide descriptive statistics for the Web 2.0 scale question. In addition, during the analysis phase, examination of the survey questions revealed that a few questions could have been worded more clearly and a pair of related questions (Q1 & Q51) did not correspond to each other well. However, this did diminish much from the overall analytical power of the survey.

Implications

As was discussed earlier, this study is unique given its construction and validation of a survey measuring pre-service teachers' science and Web 2.0 motivation, self-efficacy, attitude, and aspiration, and its items match the Ontario science curriculum expectations. From the design of the instrument and the findings of the research, the following recommendations are put forward for pedagogical or policy implications.

First, the results evidently demonstrate that time spent on learning about science, regardless of using Web 2.0 or not, has a positive correlation with science affect; moreover, the positive correlation effect is very obvious for science aspiration; very little science learning time (less than one hour per week) has a significant negative effect on science affects ($p < 0.05$). Though this study has not clearly determined which variable was dependent on the other, the school curriculum developers, especially the Bachelor of Education personnel, must have a clear sense of the science exposure required for the BEd program. Even though Primary-Junior and Junior-Intermediate streams might not contain STEM-related specialty areas (Western University, 2017) due to the limited conditions in the current teacher education program, there remains some grounds for increasing the pre-service teachers' connections with science by communicating with science professionals, participating in science-related activities or games, or attending science-related internships, etc. It is worth noting that not only science teachers, but every teacher impacts students intentionally or unintentionally whenever teaching courses or communicating with students. These impacts thereby affect their students' academic affects towards science, thus influencing their STEM-related academic performance and potential careers. Following this study, teacher education policy makers could arrange more STEM-related activities, conferences or other social communications for non-STEM-related pre-service teachers to encourage them to promote science.

Moreover, Web 2.0 as a tool for science learning could accomplish great improvements. The descriptive statistics indicate that pre-service teachers were keen on using Web 2.0 technologies in their daily lives, and showed strong interest and a positive attitude towards using Web 2.0 as a tool for studying in general or learning science. Paradoxically, only a small proportion of them often used Web 2.0 for science purposes or are skilled in using Web 2.0 for science learning. To tackle this issue, science policy makers should encourage or reward well-designed science learning/teaching Web 2.0 tools for students for all age groups, and open Web 2.0-assisted science learning/teaching courses for students, pre-service teachers, and even for in-service teachers.

Future Considerations

While the research put forward a science affects measurement for Ontario pre-service teachers, and explored some predictors of science motivation, self-efficacy, attitude and aspiration, there is still a necessity for further research. From the limitations and extension of the study, the following considerations could be implemented.

Make the Study Stronger.

As the limitations mentioned above show, there were only 134 valid responses – the sample size was imperfect as the homogeneity of the sample (gender, grade, race) was tentative. In addition, the limited sample size could be a key reason for the failure of the Web 2.0 scale questions not passing the PCA test. As this time, more than 80% of participants were first-year pre-service teachers, more second-year students could be involved in the future. Furthermore, I surveyed only the BEd students at the Faculty of Education at Western University. The next step is to expand the target population by surveying other pre-service teachers at other teacher education programs in Ontario.

Dig Deeper.

Although the study to an extent revealed pre-service teachers' science affect, science learning and Web 2.0 utilizing habits and explored the relationships between affect and demographic factors, the reasons behind these phenomena remain to be explored. Further research should involve some qualitative study like interviews or audio-visual materials, to further understand their science and Web 2.0 learning/usage habits to reveal the deeper underlying reasons behind these predictor variables.

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Appendices

Appendix A: Western Ethics Approval

Date: 10 January 2018

To: Dr. Anton Puvirajah

Project ID: 110279

Study Title: Pre-service Teachers' Science and Web 2.0 Affect and Aspiration

Application Type: NMREB Initial Application

Review Type: Delegated

Full Board Reporting Date: February 2 2018

Date Approval Issued: 10/Jan/2018

REB Approval Expiry Date: 10/Jan/2019

Dear Dr. Anton Puvirajah

The Western University Non-Medical Research Ethics Board (NMREB) has reviewed and approved the WREM application form for the above mentioned study, as of the date noted above. NMREB approval for this study remains valid until the expiry date noted above, conditional to timely submission and acceptance of NMREB Continuing Ethics Review.

This research study is to be conducted by the investigator noted above. All other required institutional approvals must also be obtained prior to the conduct of the study.

Documents Approved:

Document Name	Document Type	Document Date	Document Version
WSSWAA Pre-service Teacher - Brochure Cards 20171215	Recruitment Materials	15/Dec/2017	3
WSSWAA Pre-service Teacher - Classroom Recuitment Script 20171215	Recruitment Materials	15/Dec/2017	3
WSSWAA Pre-service Teacher - Course Instructor Communicate Letter 20171031	Recruitment Materials	31/Oct/2017	
WSSWAA Pre-service Teacher - Letter of Information and Consent- 20171215 v2	Implied Consent/Assent	15/Dec/2017	3
WSSWAA Pre-service Teacher - Online Survey Questions 20171101	Online Survey	01/Nov/2017	
WSSWAA Pre-service Teacher - Recruitment Email Script 20171215	Recruitment Materials	15/Dec/2017	3
WSSWAA Pre-service Teacher - Recruitment Poster 20171215	Recruitment Materials	15/Dec/2017	3

Documents Acknowledged:

Document Name	Document Type	Document Date	Document Version
WSSWAA Pre-service Teacher - Screening Questionnaire 20171214	Screening Form/Questionnaire	14/Dec/2017	

No deviations from, or changes to the protocol should be initiated without prior written approval from the NMREB, except when necessary to eliminate immediate hazard(s) to study participants or when the change(s) involves only administrative or logistical aspects of the trial.

The Western University NMREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the Ontario Personal Health Information Protection Act (PHIPA, 2004), and the applicable laws and regulations of Ontario. Members of the NMREB who are named as

Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB. The NMREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000941.

Please do not hesitate to contact us if you have any questions.

Sincerely,

Kelly Patterson, Research Ethics Officer on behalf of Dr. Randal Graham, NMREB Chair

Note: This correspondence includes an electronic signature (validation and approval via an online system that is compliant with all regulations).

Amendment 1

Date: 28 February 2018

To: Dr. Anton Puvirajah

Project ID: 110279

Study Title: Pre-service Teachers' Science and Web 2.0 Affect and Aspiration

Application Type: NMREB Amendment Form

Review Type: Delegated

Full Board Reporting Date: April 6 2018

Date Approval Issued: 28/Feb/2018

REB Approval Expiry Date: 10/Jan/2019

Dear Dr. Anton Puvirajah,

The Western University Non-Medical Research Ethics Board (NMREB) has reviewed and approved the WREM application form for the amendment, as of the date noted above.

Documents Approved:

Document Name	Document Type	Document Date	Document Version
WSSWAA Pre-service Teacher - Online Survey Questions 20180226 clean	Online Survey	26/Feb/2018	2

REB members involved in the research project do not participate in the review, discussion or decision.

The Western University NMREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the Ontario Personal Health Information Protection Act (PHIPA, 2004), and the applicable laws and regulations of Ontario. Members of the NMREB who are named as Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB. The NMREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000941.

Please do not hesitate to contact us if you have any questions.

Sincerely,

Kelly Patterson, Research Ethics Officer on behalf of Dr. Randal Graham, NMREB Chair

Note: This correspondence includes an electronic signature (validation and approval via an online system that is compliant with all regulations).

Amendment 2

Western Research

Date: 23 March 2018

To: Dr. Anton Puvirajah

Project ID: 110279

Study Title: Pre-service Teachers' Science and Web 2.0 Affect and Aspiration

Application Type: NMREB Amendment Form

Review Type: Delegated

Full Board Reporting Date: April 6 2018

Date Approval Issued: 23/Mar/2018

REB Approval Expiry Date: 10/Jan/2019

Dear Dr. Anton Puvirajah,

The Western University Non-Medical Research Ethics Board (NMREB) has reviewed and approved the WREM application form for the amendment, as of the date noted above.

Documents Approved:

Document Name	Document Type	Document Date	Document Version
WSSWAA Pre-service Teacher - Brochure Cards 20180307 clean	Recruitment Materials	07/Mar/2018	1
WSSWAA Pre-service Teacher - Letter of Information and Consent-20180307 clean	Implied Consent/Assent	07/Mar/2018	1
WSSWAA Pre-service Teacher - Recruitment Email Script 20180307 clean	Recruitment Materials	07/Mar/2018	1
WSSWAA Pre-service Teacher - Recruitment Poster 20180307 clean	Recruitment Materials	07/Mar/2018	1

REB members involved in the research project do not participate in the review, discussion or decision.

The Western University NMREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the Ontario Personal Health Information Protection Act (PHIPA, 2004), and the applicable laws and regulations of Ontario. Members of the NMREB who are named as Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB. The NMREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000941.

Please do not hesitate to contact us if you have any questions.

Sincerely,

Kelly Patterson, Research Ethics Officer on behalf of Dr. Randal Graham, NMREB Chair

Note: This correspondence includes an electronic signature (validation and approval via an online system that is compliant with all regulations).

Appendix B: Letter of Information and Consent

Western Education

Project Title

Pre-Service Teachers' Science and Web 2.0 Affect and Aspiration

Investigators

Anton Puvirajah – Principal Investigator, [redacted]

Yu Song – Graduate Student Investigator, [redacted]

Faculty of Education

The University of Western Ontario, London, ON, CA

Phone: [redacted]

Letter of Information and Consent

1. **Invitation to Participate**

   You are invited to participate in a survey study which is an important part of a Western Graduate Thesis. This study is designed to help us understand more about pre-service teachers' opinion about science and Web 2.0 technology. Your participation in the study and responses to the survey are much appreciated.

2. **Purpose of the Letter**

   The purpose of this letter is to provide you with information required for you to make an informed decision regarding participation in this study.

3. **Purpose of this Study**

   The purpose of this study is to help us understand pre-service teachers' opinions, and experiences about learning science and using Web 2.0 tools.

4. **Inclusion Criteria**

   To be eligible to participate in this study you must be a pre-service teacher enrolled in the Ontario Teacher Certification program at a University and over 18 years of age.

5. **Study Procedures**

   If you agree to participate, you will be asked to complete an anonymous online survey. The survey will take approximately 10 minutes to complete. The survey questions are mainly classified into two kinds: Multiple choices and Rating scale questions. No identifiable, sensitive, emotional distressing questions will be asked.

6. **Possible Risks and Harms**

   There are no known or anticipated physical or psychological risks or discomforts associated with participating in this study.

7. **Possible Benefits**

   You may not directly benefit from participating in this study. There may be benefits to society, in that the study has the potential to provide teacher education faculties and school districts with better understanding of pre-service teachers' science and Web 2.0 affect so that they can adjust program and professional development offerings.

8. **Voluntary Participation**

   You can stop participating in the study at any time by not completing the online survey and closing the browser window. However, once you submit your survey, we will not be able to remove your submitted information since the submission is anonymous.

9. **Confidentiality**

   Representatives of The University of Western Ontario Non-Medical Research Ethics Board may require access to study-related records to monitor the conduct of the research. The survey data will be anonymous and will not contain any information that will identify you personally. If you choose to submit your email address for the draw for the Amazon gift card, your email address will not be associated with the competed survey. Your email address will only be used to conduct the draw. Data collected will be stored electronically in encrypted files and password protected computers at the Faculty of Education. The information collected in the study is kept on file in a secure location for no less than 7 years.

10. **Compensation**

    In appreciation of your time, if you wish you can enter into a draw to win one of five $10 gift cards to Amazon by submitting your university email address at the end of the survey. Your email address and the responses to the survey will be collected separately to maintain anonymity. Only successfully drawn participants will be notified.

11. **Rights of Participants**

    Your participation in this study is voluntary. You may decide not to be in this study. Even if you consent to participate you have the right to not answer individual questions or to withdraw from the study at any time. If you choose not to participate or to leave the study at any time it will have no effect on your academic standing. If you decide to withdraw from the study, you can do so by not completing the online survey. There is no limitation on the withdrawal while completing the survey. However, once the survey is submitted, you cannot undo or ask us to withdraw the survey as the survey is obtained anonymously. Still, you may request us to withdraw yourself from the draw if you submitted our email address.

You do not waive any legal right by signing this consent form.

12. Contacts for Further Information

If you have questions about this research study please contact the Yu Song, Graduate Student Investigator, Faculty of Education, University of Western Ontario, [redacted], email: [redacted] OR Dr. Anton Puvirajah, Principal Investigator and Supervisor, Faculty of Education, University of Western Ontario,[redacted], email: [redacted].

If you have any questions about your rights as a research participant or the conduct of this study, you may contact The Office of Human Research Ethics [redacted], email: [redacted].

13. Publication

If the results of the study are published, your name or any potentially identifying information will not be used. Your email address may be collected for the use of disseminating results. If you would like to receive a copy of any potential study results, please provide your email address at the end of the survey. Your email address and the responses to the survey will be collected separately to maintain anonymity.

14. Consent

When you click the next page “>>” button, you will be asked to indicate your voluntary agreement to participate by affirming (click “Yes” to) the following items:

I indicate my voluntary agreement to participate by responding to the survey.

<u>This letter is yours to keep for future reference.</u>

Consent

Pre-Service Teachers' Science and Web 2.0
Affect and Aspiration

Principal Investigator: Anton Puvirajah, PhD, Assistance Professor

Student Investigator: Yu Song, Graduate Student

I indicate my voluntary agreement to participate by responding to the survey.

☒Yes

Appendix C: Western Survey of Science and Web 2.0 Affect and Aspiration

Western Education

<u>Western Survey of Science and Web 2.0 Affect and Aspiration</u>

For each question below, please indicate your best response. There are no right or wrong answers; we just want to find out about your opinions, thoughts, and experiences on science and web 2.0 technologies. The survey is anonymous; we will not be able to identify you personally from the completed survey. Completing or not completing the survey will not affect your school grades, marks, or other benefits.

The survey has three sections. The first section deals with science questions, the second section deals with web 2.0 questions, and the third section asks demographic information. The survey should take about 20 minutes to complete.

Thank you for participating in this important survey study!

Section 1: Science Questions

Our Definition of Science

In the survey below, when we talk about **"science",** it includes **science knowledge and practice in school and out of school, and all natural and information science areas** (physics, chemistry, astronomy, earth science, biology, biochemistry, botany, zoology, computer science, medical sciences, engineering sciences, information sciences, etc.).

Please circle the letter that best fits your answer.

1. On average, per **WEEK**, how long do you study science, or participate in science-related activities (e.g. science-related reading, experiments, observation, game, camping, etc.)?
   a. 1 hour or less
   b. More than 1 hour, up to 2 hours
   c. More than 2 hours, up to 3 hours

d. More than 3 hours, up to 4 hours
e. More than 4 hours

SCALES Questions: Please circle the number that indicate your level of agreement with the following statements:

1. Strongly agree
2. Somewhat agree
3. Neither agree nor disagree
4. Somewhat disagree
5. Strongly disagree

2	I like solving challenging science problems.	1 2 3 4 5
3	If I had a choice, I would not study science.	1 2 3 4 5
4	I would be more apt to do science if I know that I will be recognized for my work.	1 2 3 4 5
5	I only took minimally necessary number of science classes for high school graduation.	1 2 3 4 5
6	In science classes/courses, I have always aimed for and worked for high marks.	1 2 3 4 5
7	When I was faced with difficulties in understanding science, I tried to use a variety of ways to overcome these difficulties.	1 2 3 4 5
8	In science classes/courses, I would do my best to perform well.	1 2 3 4 5
9	One of my aims in science classes/courses was to do better than my peers.	5 4 3 2 1
10	I believe I can understand and apply the science terminologies correctly.	1 2 3 4 5
11	I believe I can understand most of the science concepts taught in a science class.	1 2 3 4 5
12	I believe I can identify key information in science problems.	1 2 3 4 5

13	I believe I can identify the steps to solve science problems.	5 4 3 2 1
14	I believe I can observe and make clear record of a science experiment.	1 2 3 4 5
15	I believe I can use textbooks, reference books, and internet resources to help me solve a science problem.	1 2 3 4 5
16	I believe I can use clear diagrams to express science ideas.	1 2 3 4 5
17	I believe I can make clear and audience-friendly science presentations.	1 2 3 4 5
18	I believe I can use formulae and SI units to express science knowledge (e.g., force analysis, chemical reaction, genetic formula; mass, time, length, etc.).	1 2 3 4 5
19	I believe I am able to apply the science knowledge to my other academic work when appropriate.	1 2 3 4 5
20	I believe I can understand new science knowledge and make logical connections to my previous knowledge.	1 2 3 4 5
21	I believe I can explain phenomenon and solve problems in real life using my science knowledge.	1 2 3 4 5
22	I believe I can design practical plans/devices, using scientific knowledge and principles to address issues or solve problems.	1 2 3 4 5
23	Science is important to society.	1 2 3 4 5
24	Science is helpful for improving people's daily life.	1 2 3 4 5
25	I find participating in science (learning and doing) activities interesting.	1 2 3 4 5
26	I keep myself updated with the newest development in science.	1 2 3 4 5
27	I liked learning science in school.	1 2 3 4 5
28	I liked conducting science experiments in school.	1 2 3 4 5
29	I often talk about science questions with my family or friends.	1 2 3 4 5
30	I like to observe natural/scientific phenomena in my daily life.	1 2 3 4 5
31	I like to visit Museum of Science/Nature, or the Planetarium.	1 2 3 4 5
32	I try to frequently apply science knowledge in real life (e.g. cooking, gardening, sporting, etc.)	1 2 3 4 5

33	I plan to participate in science related formal professional development activities or courses in the near future that are not a required part of the program.	1 2 3 4 5
34	I plan to keep myself updated with the newest developments in science.	5 4 3 2 1
35	I plan to participate in informal science related activities outside of my formal certification program. (e.g. robotics clubs, science museums, maker spaces)	1 2 3 4 5
36	I plan on enrolling in a science-related post-secondary program.	1 2 3 4 5
37	I plan on taking at least one science-related course from a post-secondary institution.	1 2 3 4 5
38	I will keep learning science even if it was not required in my profession.	1 2 3 4 5
39	I would seriously consider taking some/further science-related courses so that I could be certificated/endorsed in a specific science field.	1 2 3 4 5
40	I will keep using science even if my work is not related to science.	1 2 3 4 5
41	I will encourage my future students to pursue science related coursework/careers.	1 2 3 4 5

Section 2: Web 2.0 Questions

Our Definition of Web 2.0

In this study, **Web 2.0** is a terminology that represents **a series of internet technologies**. Compared to the traditional internet technologies (Web 1.0), it does not matter the devices or platforms that users use, but **to organize the contents and take advantage of the data made by every user**. The characteristics that distinguish Web 2.0 from Web 1.0 are significant: the traditional Web 1.0 technologies are more static, administrator-centered, non-interactive, whose contents are provided by the authors. In comparison, Web 2.0 tools are more dynamic, user-centered, interactive, socialized, collaborated, to make every user becoming the author of the contents (O'Reilly in Donelan et al. 2010, p. 223; Lee & Markey, 2014).

The representative technologies of Web 2.0 tools include **blogging, wiki, podcasting, RSS, social bookmarking, social media, social network, and so on.**

Please circle the letter that best fits your answer. (Web 2.0 general questions)

42. Please select the mobile devices you regularly use. You can choose more than one option. If you own more than one device in a option, please specify the number behind the option.
    a. Smartphone
    b. Tablet
    c. Smartwatch or activity-tractor
    d. Others (Please specify)________________
    e. I don't have any
43. On average, how much time per week do you spend using your mobile devices?
    a. 3.5 hours or less
    b. More than 3.5 hours, up to 7 hours
    c. More than 7 hours, up to 10.5 hours
    d. More than 10.5 hours, up to 14 hours
    e. More than 14 hours

44. Please select the class of Web 2.0 tools you **use** frequently (please see the examples below). You can choose more than one.
    a. Blogging (e.g., Blogger, Tumblr, WordPress, etc.)
    b. Wikis (e.g., Wikipedia, Pbwiki, etc.)
    c. Podcasting (e.g., iTunes, ePodcast, myPod, etc.)
    d. RSS (e.g., Feedly, Panda, Feedbin, etc.)
    e. Social bookmarking (e.g., Pinterest, Reddit, Google Bookmark, digg, etc.)
    f. Social media & social network (e.g., YouTube, Facebook, WhatsApp, WeChat, Instagram, Twitter, LinkedIn, etc.)
    g. Massively multiplayer online interactive games (e.g., League of Legends, Overwatch, World of Warcraft)
    h. Virtual Worlds/Virtual World Communities (e.g., Second Life, Twinity)
    i. Online learning platform (e.g., OWL, Duolingo, Khan Academy)
    j. Others (Please specify)________________
    k. I never use any
45. Please select the **primary interests** when you to use Web 2.0 tools. You can choose up to 3 options.
    a. Communicating, socializing
    b. Playing, entertainment
    c. Learning
    d. Creating, producing
    e. Managing (time/task/to-do list, etc.)
    f. Others (Please specify)________________
    g. I never used any
46. How do you rate your proficiency of using Web 2.0 tools?
    a. Expert/Very familiar with
    b. Advanced/Familiar with
    c. Intermediate
    d. Novice/Not very familiar with
    e. Very basic/Not familiar with
    f. Never used

47. I find the use of **MY** Web 2.0 tools to be very convenient and user friendly.
    a. Strongly Agree
    b. Agree
    c. Neither Agree or Disagree (Neutral) / Intermediate
    d. Disagree / Not very user-friendly
    e. Strongly Disagree / Not user-friendly
    f. Never used
48. During your **high school experience**, in which of the following subjects did you use Web 2.0 tools? You can choose more than one option.
    a. the arts
    b. guidance and career education
    c. business studies
    d. health and physical education
    e. Canadian and world studies
    f. classical studies and languages studies
    g. mathematics
    h. computer studies
    i. English
    j. Native studies
    k. English as a second language and English literacy development
    l. science
    m. social sciences and humanities
    n. French as a second language
    o. technological education
    p. Others (Please specify)________________
    q. None
49. Please select the class of Web 2.0 tools you **currently** use for learning purpose (please see the examples below). You can choose more than one option.
    a. Blogging (e.g., Blogger, Tumblr, WordPress, etc.)
    b. Wikis (e.g., Wikipedia, Pbwiki, etc.)
    c. Podcasting (e.g., iTunes, ePodcast, myPod, etc.)

d. RSS (e.g., Feedly, Panda, Feedbin, etc.)
e. Social bookmarking (e.g., Pinterest, Reddit, Google Bookmark, digg, etc.)
f. Social media & social network (e.g., YouTube, Facebook, WhatsApp, WeChat, Instagram, Twitter, LinkedIn, etc.)
g. Massively multiplayer online interactive games (e.g., League of Legends, Overwatch, World of Warcraft, etc.)
h. Others (Please specify)________________
i. I never use any

50. On average, how much time per week do you use the Web 2.0 tools for **learning**?
    a. 2 hours or less
    b. More than 2 hours, up to 4 hours
    c. More than 4 hours, up to 6 hours
    d. More than 6 hours, up to 8 hours
    e. More than 8 hours
51. On average, how much time per week do you use the Web 2.0 tools for **Science Learning**?
    a. 2 hours or less
    b. More than 2 hours, up to 4 hours
    c. More than 4 hours, up to 6 hours
    d. More than 6 hours, up to 8 hours
    e. More than 8 hours

SCALES Questions: Please circle the number that indicate your level of agreement with the following statements:

1. Strongly agree/Always
2. Agree/Usually
3. Undecided/Sometimes
4. Disagree/Rarely
5. Strongly disagree/Never

52	Web 2.0 technology is useful in my studying.	1 2 3 4 5

53	Mobile apps are distracting for learning.	1 2 3 4 5
54	Web 2.0 apps have more advantages than disadvantages in learning.	1 2 3 4 5
55	Web 2.0 technology is helpful for learning science.	1 2 3 4 5
56	I would like to use Web 2.0 tools for studying.	1 2 3 4 5
57	I would enjoy using science-related web 2.0 apps (also include science-based puzzle games) for learning.	1 2 3 4 5
58	I would not use science-related Web 2.0 tools for studying, because I would be mistaken for playing rather than studying.	1 2 3 4 5
59	I'm good at using web 2.0 tools to study.	1 2 3 4 5
60	I'm good at using web 2.0 tools to study science.	5 4 3 2 1
61	I would like to use Web 2.0 apps to help me learn science if I were in school.	1 2 3 4 5
62	I would like to use Web 2.0 apps to help me learn science out of school.	1 2 3 4 5
63	I would like to use Web 2.0 apps to help me learn science even after my graduation from university or college.	1 2 3 4 5

Demographic Questions

For the survey questions below, please circle the letter that best fits your answer.

64. What program are you in now?
    a. Primary-Junior (Please go to question 65)
    b. Junior-Intermediate (Please go to question 66)
    c. Intermediate-Senior (Please go to question 69)
    d. Others (please specify) ___________ (Please go to question 72)

Depending on your options, please only answer the questions responding to your answer in question 64.

65. Primary-Junior: Please choose your Specialty Area:
    a. International Education
    b. Early Childhood Education
    c. Urban Education
    d. French (Elementary)
    e. Advanced Studies in the Psychology of Achievement, Inclusion, & Mental Health
    f. Mathematics Through the Arts
    g. Others (please specify) ___________

Primary-Junior: Please go to question 72

66. Junior-Intermediate: Please choose your first Teaching Area/Option.
    a. French
    b. Music
    c. Religious Education
    d. Others (please specify) ___________
67. Junior-Intermediate: Please specify your second Teaching Area/Option:

    ____

68. Junior-Intermediate: Please choose your Specialty Area:
    a. International Education

b. Urban Education
c. French (Elementary)
d. Advanced Studies in the Psychology of Achievement, Inclusion, & Mental Health
e. Others (please specify) ___________

Junior-Intermediate: Please go to question 72

69. Intermediate-Senior: Please choose your first Teaching Area/Option.
    a. Economics
    b. English (First Language)
    c. Environmental Science
    d. Family Studies
    e. French (Second Language)
    f. Geography
    g. Health & Physical Education
    h. History
    i. Law
    j. Mathematics
    k. Music – instrumental/vocal
    l. Philosophy
    m. Politics
    n. Religious Education
    o. Science – biology/chemistry/general/physics
    p. Social Studies – General
    q. Others (please specify) ___________
70. Intermediate-Senior: Please type in your second Teaching Area/Option:

    ____
71. Intermediate-Senior: Please choose your Specialty Area:
    a. International Education
    b. STEM Education
    c. Urban Education
    d. French (Secondary)

e. Advanced Studies in the Psychology of Achievement, Inclusion, & Mental Health
f. Others (please specify) __________

72. What is your __________teaching specialty? (Please specify) ______________
73. Please select all your educational attainments (completed)?
    a. High school (or secondary school) graduate
    b. Some postsecondary education
    c. Trade/vocational diploma or certificate
    d. College diploma or certificate
    e. Bachelor's degree
    f. Professional degree (e.g., MD, LLB, DDS)
    g. Master's degree
    h. Doctoral degree
    i. Not applicable.
74. What is your educational background? You may indicate more than one if applicable.
    a. Agriculture
    b. Arts (art, music, theater, etc.)
    c. Biological/Life sciences (biology, biochemistry, botany, zoology, etc.)
    d. Business and administration, economics (accounting, business administration, marketing, management, etc.)
    e. Communication (TV, radio, speech, journalism, etc.)
    f. Computer or information sciences
    g. Cultural, ethnic studies
    h. Education
    i. Engineering or architecture
    j. Hospitality or service industry
    k. Humanities, literature and languages (English, foreign languages, philosophy, religion, etc.)
    l. Law, public administration, multidisciplinary studies (city management, international relations, environmental studies, sports management, leisure studies, etc.)

m. Manufacturing and construction,
n. Medical sciences, health-related sciences, social services
o. Personal services, transport services, security services
p. Physical sciences, mathematics (mathematics, physics, chemistry, astronomy, earth science, etc.)
q. Social and behavioral sciences (political science, psychology, sociology, anthropology, etc.)
r. There is no option that applies to me (please specify) ___________

75. I have a science related major from a post-secondary institution.
    a. Yes
    b. No
76. What is your gender?
    You are welcome to provide your self-chosen gender identity here __________
77. What is your age?
    a. Under 20 years old
    b. 20-24 years old
    c. 25-29 years old
    d. 30-34 years old
    e. 35 years old and above
78. Ethnicity origin (or Race): Please specify your ethnicity. You can choose more than one if needed.
    a. White
    b. North American Aboriginal
    c. South Asian (e.g., East Indian, Pakistani, Sri Lankan, etc.)
    d. Chinese
    e. Black
    f. Filipino
    g. Latin American
    h. Arab
    i. Southeast Asian (e.g., Vietnamese, Cambodian, Laotian, Thai, etc.)
    j. West Asian (e.g., Iranian, Afghan, etc.)

k. Korean
l. Japanese
m. There is no option that applies to me. I identify my ethnicity as (please specify) ____

79. What is the highest educational attainment of your Mother (or legal female guardians, if applicable)?
    a. Less than secondary school/high school
    b. High school (or secondary school) graduate
    c. Some postsecondary education
    d. Trade/vocational diploma or certificate
    e. College diploma or certificate
    f. Bachelor's degree
    g. Professional degree (e.g., MD, LLB, DDS)
    h. Master's degree
    i. Doctoral degree
    j. Not applicable
    k. Don't know
80. What is your Mother's profession (or legal female guardians, if applicable)? You may indicate more than one if applicable.
    a. Agriculture
    b. Arts (art, music, theater, etc.)
    c. Biological/Life sciences (biology, biochemistry, botany, zoology, etc.)
    d. Business and administration, economics (accounting, business administration, marketing, management, etc.)
    e. Communication (TV, radio, speech, journalism, etc.)
    f. Computer or information sciences
    g. Cultural, ethnic studies
    h. Education
    i. Engineering or architecture
    j. Hospitality or service industry

k. Humanities, literature and languages (English, foreign languages, philosophy, religion, etc.)
l. Law, public administration, multidisciplinary studies (city management, international relations, environmental studies, sports management, leisure studies, etc.)
m. Manufacturing and construction,
n. Medical sciences, health-related sciences, social services
o. Personal services, transport services, security services
p. Physical sciences, mathematics (mathematics, physics, chemistry, astronomy, earth science, etc.)
q. Social and behavioral sciences (political science, psychology, sociology, anthropology, etc.)
r. There is no option that applies to me (please specify) ___________
s. Not applicable

81. What is the highest educational attainment of your Father (or legal male guardians, if applicable)?
    a. Less than secondary school/high school
    b. High school (or secondary school) graduate
    c. Some postsecondary education
    d. Trade/vocational diploma or certificate
    e. College diploma or certificate
    f. Bachelor's degree
    g. Professional degree (e.g., MD, LLB, DDS)
    h. Master's degree
    i. Doctoral degree
    j. Not applicable
    k. Don't know
82. What is your Father's profession (or legal male guardians, if applicable)? You may indicate more than one if applicable.
    a. Agriculture
    b. Arts (art, music, theater, etc.)

c. Biological/Life sciences (biology, biochemistry, botany, zoology, etc.)
d. Business and administration, economics (accounting, business administration, marketing, management, etc.)
e. Communication (TV, radio, speech, journalism, etc.)
f. Computer or information sciences
g. Cultural, ethnic studies
h. Education
i. Engineering, manufacturing and construction, architecture
j. Humanities, literature and languages (English, foreign languages, philosophy, religion, etc.)
k. Law, public administration, multidisciplinary studies (city management, international relations, environmental studies, sports management, leisure studies, etc.)
l. Medical sciences, health-related sciences, social services
m. Personal services, transport services, security services
n. Physical sciences, mathematics (mathematics, physics, chemistry, astronomy, earth science, etc.)
o. Social and behavioral sciences (political science, psychology, sociology, anthropology, etc.)
p. There is no option that applies to me (please specify) ___________
q. Not applicable

------ *END OF SURVEY*------

Curriculum Vitae

Name:	Yu Song
Year of Birth:	1988
Post-secondary Education and Degrees:	Qingdao University Qingdao, Shandong, China 2007 - 2011, B. Sc. Western University London, Ontario, Canada 2016 - 2018, M. A.
Related Work Experience:	Secondary School Intern Chemistry Teacher Qingdao Experimental Junior High School of Shandong Province 2010 Vocational Computer Science School Academic Advisor QST Education Group 2012 - 2015